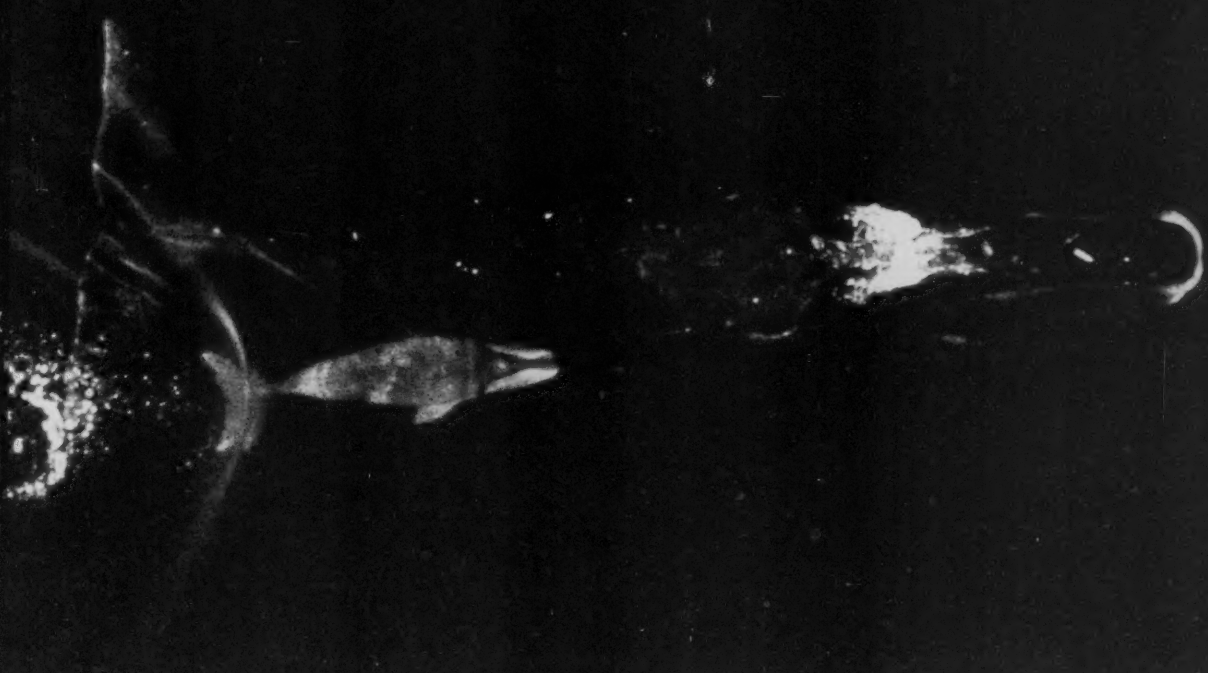




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The Bowhead Whale

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On the cover:
Bowhead whale
and calf near Point
Barrow, Alaska, during
the 1992 spring migration.
Photo by Robin Westlake, NMFS.



Articles

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1

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The Geographic Distribution of Bowhead Whales, *Balaena mysticetus*, in the Bering, Chukchi, and Beaufort Seas: Evidence from Whaleship Records, 1849–1914

JOHN R. BOCKSTOCE, DANIEL B. BOTKIN, ALEX PHILP,
BRIAN W. COLLINS, and JOHN C. GEORGE

Introduction

The Scientific Committee of the International Whaling Commission (IWC) has expressed concern about the management and conservation of bowhead whales, *Balaena mysticetus*, in the Bering, Chukchi, and Beaufort (B-C-B) Seas (Map 1).¹ In particular, the committee has inquired whether "observed temporal and spatial heterogeneity" might exist within the population (IWC, 2005:19–22), resulting in "subpopulations with limited interbreeding." New DNA analyses raise the possibility that such subpopulations may exist but do

not resolve this possibility. Bockstoce and Botkin (1983:119) have speculated previously on whether subpopulations may have existed within the B-C-B population, as has Fraker (1989:267–269). Among other things, the possibility of the existence of such subpopulations has implications for conservation and management of the B-C-B bowhead stock, in this instance primarily for establishing allowable harvest levels.

In this paper we make use of a unique body of historical data from whaleships in the B-C-B bowhead fishery to help understand whether subpopulations may have existed, whether these may have been extirpated by that whale fishery, and therefore whether there is some historical basis for the claim that the stock functioned as a set of separate subpopulations.

Three decades ago, the U.S. Government and the IWC's Scientific Committee recommended a moratorium on the Eskimo harvest of B-C-B bowheads because of the high (and then increasing) strike rate, combined with imprecise estimates that the whale population was low. As a result of this controversy, Bockstoce and Botkin (1983) examined all existing records of the historical commercial whaling industry to estimate both the size of the bowhead population that existed at the beginning of the commercial harvest and the size of the harvest over time. These data comprise more than 65,000 days of observations representing 19% of all known whaling cruises to those waters from the second year of the fishery until its collapse. These records span the years from 1849 to 1914 in an unbroken series. Among

much other recorded information, the logbook records include the locations of ships on days when one or more whales were captured.

Historical Data Resources and Methods

The Bering Strait whaling grounds were discovered by one ship, the bark *Superior* of Sag Harbor, New York, under the command of Captain Thomas W. Roys, in 1848, and in 1849 a whaling fleet began a hunt that continued until 1914. During this period whaleships carried out 2,712 annual cruises to the Bering, Chukchi, and Beaufort Seas (B-C-B).² Complete records of 516 of the annual cruises were found in logbooks and journals in public and private collections throughout the United States, Canada, and Australia—19% of the total number of annual cruises. These provide an unbroken record of the whale hunt in the B-C-B from 1849 to 1914.

From these logbooks and journals, 65,137 days³ of observations were

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ABSTRACT—We have extracted, digitized, and analyzed information about bowhead whales, *Balaena mysticetus*, contained in records of whaling cruises that were undertaken in the Bering, Chukchi, and Beaufort Seas from 1849 to 1914. Our database consists of 65,000 days of observations which provide insights into whether this bowhead stock may comprise more than one population.

¹Maps showing bowhead whale range and captures during various periods are located on pages 13–43.

²For readers not familiar with historical whaling terminology, we note that a voyage was the trip made from home port to home port (for example, from New Bedford, Mass., to the whaling grounds, and return), while a cruise was a portion of a voyage that took place on a particular whaling ground. For example, in a multi-year voyage to the Pacific Ocean, a ship might make two or three Arctic cruises, as well as several to other whaling grounds, and would resupply between cruises in Hawaii or San Francisco.

³The researchers originally abstracted more than 66,000 records, but some of the ship locations were entered into our database erroneously, placing the ships' positions on land. These were omitted from the analysis.

Table 1.—Recorded captures of bowhead whales in the fishery, 1849–1914. Our database represents 19.03% of all annual whaling cruises in this fishery. The documented captures are those bowheads that were captured and processed; documented days are those ships-days spent in the B-C-B fishery; CPUE (catch per unit of effort) is the average number of bowhead captures per day spent by whaleships in the B-C-B fishery; days per catch are the average number of days spent by a ship to catch a bowhead in the B-C-B fishery; and documented cumulative captures are the cumulative number of documented bowhead whales caught. CPUE, a commonly used term in studies of fishery and marine mammal harvests, is defined here as the captures per day spent cruising in the B-C-B fishery and is used with this meaning throughout this report, unless if otherwise noted. (Source: Bockstoe and Botkin, 1983:115).

Year	Documented captures	Documented days	CPUE	Days per catch	Documented cumulative captures
1849	71	482	0.15	6.79	71
1850	316	2,619	0.12	8.29	387
1851	142	3,355	0.04	23.63	529
1852	381	5,241	0.07	13.76	910
1853	101	3,327	0.03	32.94	1,011
1854	21	1,148	0.02	54.67	1,032
1855	0	231	0.00	—	1,032
1856	0	41	0.00	—	1,032
1857	12	152	0.08	12.67	1,044
1858	83	1,905	0.04	22.95	1,127
1859	78	1,775	0.04	22.76	1,205
1860	43	1,199	0.04	27.88	1,248
1861	65	1,140	0.06	17.54	1,313
1862	45	708	0.06	15.73	1,358
1863	74	1,148	0.06	15.51	1,432
1864	94	2,109	0.04	22.44	1,526
1865	103	2,063	0.05	20.03	1,629
1866	149	3,257	0.05	21.86	1,778
1867	191	4,125	0.05	21.60	1,969
1868	114	2,256	0.05	19.79	2,083
1869	89	1,733	0.05	19.47	2,172
1870	162	2,168	0.07	13.38	2,334
1871	29	1,041	0.03	35.90	2,363
1872	42	1,065	0.04	25.36	2,405
1873	21	776	0.03	36.95	2,426
1874	15	537	0.03	35.80	2,441
1875	30	366	0.08	12.20	2,471
1876	3	184	0.02	61.33	2,474
1877	53	719	0.07	13.57	2,527
1878	9	443	0.02	49.22	2,536
1879	7	195	0.04	27.86	2,543
1880	59	448	0.13	7.59	2,602
1881	17	188	0.09	11.06	2,619
1882	15	254	0.06	16.93	2,634
1883	3	563	0.01	187.67	2,637
1884	6	340	0.02	56.67	2,643
1885	27	719	0.04	26.63	2,670
1886	12	509	0.02	42.42	2,682
1887	15	521	0.03	34.73	2,697
1888	15	833	0.02	55.53	2,712
1889	4	697	0.01	174.25	2,716
1890	13	651	0.02	50.08	2,729
1891	41	1,111	0.04	27.10	2,770
1892	35	841	0.04	24.03	2,805
1893	16	756	0.02	47.25	2,821
1894	30	906	0.03	30.20	2,851
1895	22	583	0.04	26.50	2,873
1896	14	741	0.02	52.93	2,887
1897	19	836	0.02	44.00	2,906
1898	54	609	0.09	11.28	2,960
1899	51	595	0.09	11.67	3,011
1900	28	561	0.05	20.04	3,039
1901	9	411	0.02	45.67	3,048
1902	33	465	0.07	14.09	3,081
1903	19	565	0.03	29.74	3,100
1904	12	387	0.03	32.25	3,112
1905	27	607	0.04	22.48	3,139
1906	9	295	0.03	32.78	3,148
1907	19	467	0.04	24.58	3,167
1908	9	541	0.02	60.11	3,176
1909	2	131	0.02	65.50	3,178
1910	4	139	0.03	34.75	3,182
1911	6	150	0.04	25.00	3,188
1912	0	0	0.00	—	3,188
1913	0	102	0.00	—	3,188
1914	10	105	0.10	10.50	3,198

extracted and digitized. These observations contain the date and geographical position of the vessel, often the wind's direction and velocity, the visibility, ice coverage, and usually the fauna encountered (for example, bowhead, gray whale, *Eschrichtius robustus*; right whale⁴, *Eubalaena glacialis*; humpback whale, *Megaptera novaeangliae*; walrus, *Odobenus rosmarus*, etc.), including the number of animals and the nature of any encounter (seen only, chased only, struck and lost likely to live, struck and lost likely to die, captured and processed, or found dead).

If a captured whale was processed, in some cases the yield in barrels of oil or pounds of baleen was recorded (Bockstoe and Botkin, 1983). In these records, 3,318 whales were stated as caught and processed (which we refer to as "captured") (Table 1). The number of whales captured was less than the number of whales killed, because the whalers also recorded animals that were struck and lost and judged likely to die (Bockstoe and Botkin, 1983:115–116).⁵

Relevance of the Historical Data to the Question of Separate Populations

What evidence do the historical data provide about the possible existence of separate populations within the B-C-B bowhead stock? To pursue an answer to this question, we must first consider whether the whalers' observations can be judged to constitute a scientifically reasonable sample. The whaleships' hunting range covered essentially all of the waters north of the southern Bering Sea, as well as the entire Chukchi Sea and the southern Beaufort Sea (Maps 2–4). Although the whaleships

⁴Few right whales were taken in the B-C-B fishery, although they were sought in the southeastern Bering Sea from time to time. The whalers made clear distinctions between bowheads and right whales.

⁵To gather this information Bockstoe first identified all whaleships that hunted bowheads in the B-C-B fishery. He did this by consulting nineteenth and early twentieth century shipping newspapers and cross-checking these data with insurance industry information and with reports in logbooks and journals of other ships that were seen on the whaling grounds.

did not conduct the equivalent of a scientific and statistically valid random sample, they appear to have searched in essentially all of the waters within which they believed bowhead whales might have existed. As a result, we believe that the documented locations of the bowhead sightings and captures (Map 2) provide a relatively accurate representation of the total known range of the B-C-B bowhead population during the 1849–1914 whaling seasons.

Map 2 also suggests that the whalers, once they had seen bowheads, were relatively successful at capturing them: There is a close overlap between the locations of whale sightings and captures. Maps 2, 3, and 4 thus indicate that the whalers covered quite thoroughly the geographic area where bowheads were known and that the historical data can be treated as representative of the geographic distribution of the whales.

History of the Fishery

It is important to recognize several fundamental realities of the B-C-B bowhead fishery:

- The commercial whale hunt was an economically rational attempt to acquire raw materials (whale oil and baleen) as cheaply (quickly) as possible.
- The commercial whale hunt was not a random search. The whalers used their best judgment about where to find bowheads, and they were constantly on the alert for them.
- Whalers only traveled as far as necessary to reach their quarry. Purely exploratory cruises were rarely undertaken.
- Whalers cruised on the whaling grounds only as long as it was necessary to fill their ship. In the early years of the fishery, ships occasionally became "full" and left the whaling grounds before the hunting season ended; in the latter years this rarely occurred.
- Whalers sought bowheads exclusively (because of their high yields of oil and baleen); if no bowheads were present, they would take any

available alternative species, principally gray whales and walrus.

- Whalers almost always pursued the nearest bowhead, and it was extremely rare for them to be selective as to the size of the bowheads they chased, with the exception of calves, which were not sought.
- Ice coverage and weather conditions limited the whalers' hunting ability and the ships' cruising range. In the spring and summer the whalers could only progress as far as the retreating pack ice would allow. Throughout the cruise, fog and gales also hampered their ability to hunt.

Although a few bowheads were taken commercially in the southwesternmost waters of the Bering Sea between about 1840 and 1847, these whales were not deliberately sought until 1848, when Captain Thomas Roys sailed a thousand miles beyond the nearest whaling ship and, finding large numbers of bowheads, discovered the whaling grounds near Bering Strait, where he probably captured fifteen (Bockstoe, 1986:21–26). Word of these new whaling grounds spread quickly, and the following year 50 vessels enjoyed Roys' success. The news of the 1849 season lured other ships north in increasing numbers until, in 1852, the largest annual fleet, more than 200 whaling ships, operated near Bering Strait (Map 5 shows locations of whales caught during this first 5-year period).

The whalers quickly established a routine that they would vary only slightly for the next six decades. Leaving New England in the autumn and rounding Cape Horn in the southern summer, they usually outfitted at Hawaiian ports or, later, wintered at San Francisco before departing on their Arctic cruise in late March to reach the pack ice of the Bering Sea a month later. They then hunted for whales constantly as they worked their way northward among the melting ice floes toward Bering Strait. Although the bowheads were able to swim easily among the floes in the pack ice, the ice severely restricted the whaling ships' movements and caused the loss of as many as 150 vessels from 1849 to 1914 (Bock-

stoe, 1986:93–102). Thus the pack ice provided the whales with some refuge.

Once the ships reached the southern Bering Sea in the spring, the whalers began to watch for bowheads, and for the next 5–6 months they usually kept themselves in constant readiness to lower their boats. When they saw a whale, if the conditions were adequate (that is, if the sea was not too rough or the ice too dense), four or five boats usually went after it. If a boat was fortunate to get close enough to a whale, the harpooner struck it with a whaling iron, and the whale would run or dive, towing the line after it until it became tired and could be approached again and killed.

The first 5-year segment of our database (1849–53, Map 5) indicates that bowheads were captured in numbers in two areas where few were taken thereafter: 1) in the southwestern Bering Sea and 2) near the northern shore of the Chukchi Peninsula at about lat. 67°N, long. 171°W. For a few years the whalers called this area the "Cow Yard" because of the large number of female whales taken there in 1849.

In the first decade of the fishery, the whalers were successful throughout the season, but as the fishery progressed into its second decade (Maps 6–8 and 19–23), after their spring encounters with the bowheads, they generally would not see them again until late July or early August (Maps 24–26), when the retreating ice allowed the ships to reach the whales again in the Chukchi Sea. In September and early October, the whaling ships usually cruised in the northern Chukchi Sea, particularly near Herald Island, until the stormy weather and encroaching ice of autumn drove them back to ports in the Pacific Ocean (Maps 27–29).

Within 10 years of the beginning of the fishery (by 1857), the whalers had killed about 7,224 bowheads out of the more than 18,000 they would kill throughout the history of the fishery (Bockstoe and Botkin, 1983:116) (Maps 5, 6; Table 1).

Catch Per Unit of Effort

The B-C-B bowhead whale fishery followed a historical pattern similar to

Table 2.—Estimated total number of bowhead captures, 1849–1914.

Year	Documented cruises	Documented cruises as a % of total cruises	Total cruises	Bowhead captures in documented cruises	Estimated annual bowhead captures	Cumulative estimated bowhead captures
1849	7	14.00	50	71	507	507
1850	25	18.38	136	316	1,719	2,226
1851	33	18.75	176	142	757	2,984
1852	39	17.41	224	381	2,188	5,172
1853	27	16.07	168	101	629	5,801
1854	9	20.00	45	21	105	5,906
1855	3	42.86	7	0	0	5,906
1856	1	11.11	9	0	0	5,906
1857	2	16.67	12	12	72	5,978
1858	19	19.59	97	83	424	6,401
1859	20	23.26	86	78	335	6,737
1860	10	20.41	49	43	211	6,947
1861	10	22.22	45	65	293	7,240
1862	6	30.00	20	45	150	7,390
1863	9	25.71	35	74	288	7,678
1864	19	23.75	80	94	396	8,073
1865	19	22.62	84	103	455	8,529
1866	24	29.63	81	149	503	9,032
1867	28	33.73	83	191	566	9,598
1868	15	25.00	60	114	456	10,054
1869	11	26.19	42	89	340	10,394
1870	15	27.27	55	162	594	10,988
1871	10	23.26	43	29	125	11,113
1872	9	25.71	35	42	163	11,276
1873	5	14.26	35	21	147	11,423
1874	3	15.79	19	15	95	11,518
1875	3	15.00	20	30	200	11,718
1876	1	5.26	19	3	57	11,775
1877	5	21.74	23	53	244	12,019
1878	3	12.50	24	9	72	12,091
1879	1	3.50	29	7	200	12,291
1880	3	13.04	23	59	452	12,743
1881	1	4.55	22	17	374	13,117
1882	2	6.25	32	15	240	13,357
1883	3	7.69	39	3	39	13,396
1884	2	5.26	38	6	114	13,510
1885	4	9.76	41	27	277	13,787
1886	4	9.76	41	12	123	13,910
1887	3	8.33	36	15	180	14,090
1888	5	12.82	39	15	117	14,207
1889	4	9.52	42	4	42	14,249
1890	4	10.26	39	13	127	14,376
1891	7	17.95	39	41	228	14,604
1892	5	11.36	44	35	308	14,912
1893	5	11.36	44	16	141	15,053
1894	7	21.21	33	30	141	15,194
1895	7	23.33	30	22	94	15,289
1896	6	24.00	25	14	58	15,347
1897	6	26.09	23	19	73	15,420
1898	5	25.00	20	54	216	15,636
1899	4	25.00	16	51	204	15,840
1900	4	25.00	16	28	112	15,952
1901	4	33.77	13	9	27	15,978
1902	3	25.00	12	33	132	16,110
1903	3	20.00	15	19	95	16,205
1904	3	17.65	17	12	68	16,273
1905	5	31.25	16	27	86	16,360
1906	4	25.00	16	9	36	16,396
1907	3	27.27	11	19	70	16,465
1908	3	27.27	11	9	33	16,498
1909	1	20.00	5	2	10	16,508
1910	1	25.00	4	4	16	16,524
1911	1	20.00	5	6	30	16,554
1912	1	20.00	5	0	0	16,554
1913	1	20.00	5	0	0	16,554
1914	1	25.00	4	10	40	16,594
Totals	516		2,712		16,594	

other whale fisheries throughout the world (Fig. 1, 2; Table 2): The discovery of new whaling grounds resulted in large catches which were followed by declining catches. These were followed by a search for new hunting areas, a hunt for alternate species, technological innovations, and somewhat better catches, then again declining catches, and so on, until the whale population had been reduced to such a low number that it was no longer profitable (Bockstoe, 1986:324–337; Bockstoe and Botkin, 1983:116; Woodby and Botkin, 1993).⁶ In any given year, the historical, broad changes in catch per unit of effort (CPUE) were modified by ice and weather conditions of that year.

Despite the whalers' best efforts to secure a struck whale, it was a fact of life in the B-C-B fishery that some whales escaped into the ice towing lines and gear. In response to these losses, after about 1860, the whalers increasingly used darting guns (a device that was fixed to the end of the harpoon shaft and fired a small bomb into the whale as it was struck with the whaling iron) and "bomb lances" (shoulder guns that fired a similar bomb and thus generally replaced the hand lances). These innovations may have resulted in slightly increasing the CPUE (expressed as the average number of whales caught per day (Fig. 1) and the inverse, the average number of days taken to catch a whale (Fig. 2)). It is likely that improvements in technology, especially with the introduction of steamships, would increase the catch per unit effort. So that this can be investigated, we show CPUE for the sail era (Fig. 3A) and the steam era (Fig. 3B).

By about 1866 the whalers usually did not encounter many bowheads in the summer. In response, they began taking walrus and gray whales in the "middle season" between their spring

⁶In fact, we believe that should another technological advance have been introduced into the B-C-B fishery in the early years of the twentieth century, by that date the bowhead population had been so severely reduced (hence the whales were by then so difficult to find) that this putative innovation would not have improved the efficiency of the harvest.

and autumn encounters with the bowheads. However, the rise of the petroleum industry soon ended this: by 1880 whale oil and walrus oil prices were so low that profits could only be made by taking baleen (the flexible keratinous plates that hang from a bowhead's upper jaw and filter food from the water), the price of which was driven upward by, among other things, the late Victorian fashion industry for corset stays and skirt hoops.

In 1880 the rising price of baleen stimulated the development of steam-

auxiliary whaling vessels⁷, which enabled whalers to chase bowheads deeper into the ice to less accessible corners of their range. The steam whalers were based in San Francisco, marking the beginning of the last phase of the fishery (Maps 11–19), which, for clarity

⁷At the very end of the pelagic whaling era a few vessels were outfitted with internal combustion engines. The cruises of one of these, the auxiliary schooner *Polar Bear*, are documented in our database for the years 1913 and 1914. All of the other auxiliary-powered vessels in our database were steamers.

ity and convenience, we call the "Steam Era," although a number of sail-powered vessels remained active in the fishery (Bockstoce, 1977).

In 1889 the steamers reached the eastern Beaufort Sea, where, near the delta of the Mackenzie River, they discovered the summer feeding grounds of many of the remaining bowheads. From then until 1914 the industry largely concentrated on those waters (Maps 15–18).

Changes in fashion and increasing use of flexible spring steel, a cheap sub-

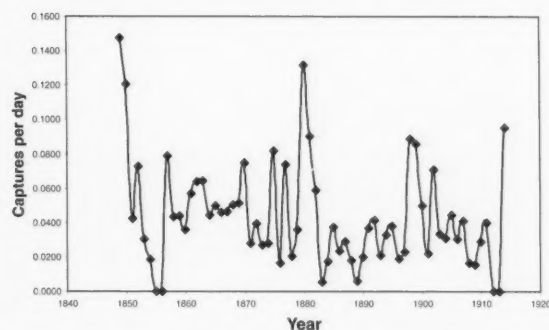


Figure 1.—Average number of whales caught per day calculated for the number of days spent by whaling ships in the B-C-B fishery area. This serves as an expression of the catch per unit of effort (CPUE).

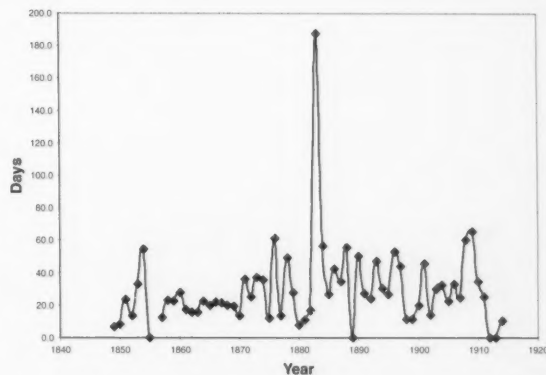


Figure 2.—Average number of days required to capture a bowhead, one measure of catch per unit of effort (CPUE). As the bowhead population was steadily reduced, the influence of ice and weather increasingly became factors in the number of bowhead captures in any year.

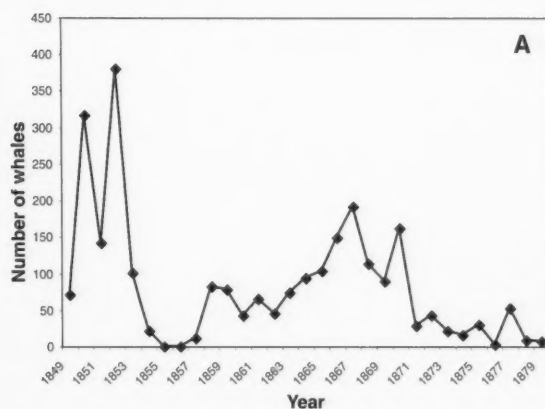


Figure 3A.—Annual captures during the "Sail Era" (1849–79) annotated by whalers' reports of bowhead availability and environmental conditions (Bockstoce and Botkin, 1983:124–125).

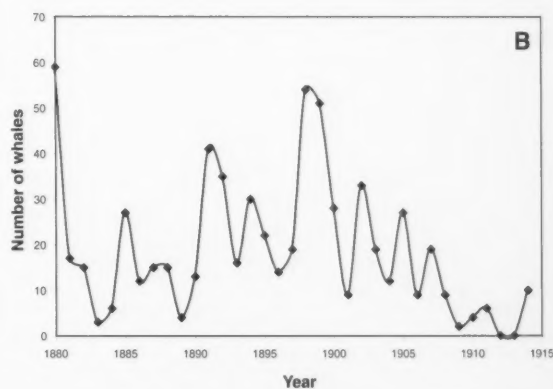


Figure 3B.—Annual captures during the "Steam Era" (1880–1914), annotated by whalers' reports of bowhead availability and environmental conditions (Bockstoce and Botkin, 1983:124–125).

Table 3.—Catch per unit of effort (CPUE) and average days to catch a bowhead whale, from the documented cruises, 1849–1914.

Year	Documented catch	Documented days	Catch per unit of effort (CPUE)	Days to catch a whale
1849	71	482	0.1473	6.8
1850	316	2,619	0.1207	8.3
1851	142	3,355	0.0423	23.6
1852	381	5,241	0.0727	13.8
1853	101	3,327	0.0304	32.9
1854	21	1,148	0.0183	54.7
1855	0	231	0.0000	
1856	0	41	0.0000	
1857	12	152	0.0789	12.7
1858	83	1,905	0.0436	23.0
1859	78	1,775	0.0439	22.8
1860	43	1,199	0.0359	27.9
1861	65	1,140	0.0570	17.5
1862	45	708	0.0636	15.7
1863	74	1,148	0.0645	15.5
1864	94	2,109	0.0446	22.4
1865	103	2,063	0.0499	20.0
1866	149	3,257	0.0457	21.9
1867	191	4,125	0.0463	21.6
1868	114	2,256	0.0505	19.8
1869	89	1,733	0.0514	19.5
1870	162	2,168	0.0747	13.4
1871	29	1,041	0.0279	35.9
1872	42	1,065	0.0394	25.4
1873	21	776	0.0271	37.0
1874	15	537	0.0279	35.8
1875	30	366	0.0820	12.2
1876	3	184	0.0163	61.3
1877	53	719	0.0737	13.6
1878	9	443	0.0203	49.2
1879	7	195	0.0359	27.9
1880	59	448	0.1317	7.6
1881	17	188	0.0904	11.1
1882	15	254	0.0591	16.9
1883	3	563	0.0053	187.7
1884	6	340	0.0176	56.7
1885	27	719	0.0376	26.6
1886	12	509	0.0236	42.4
1887	15	521	0.0288	34.7
1888	15	833	0.0180	55.5
1889	4	697	0.0057	
1890	13	651	0.0200	50.1
1891	41	1,111	0.0369	27.1
1892	35	841	0.0416	24.0
1893	16	756	0.0212	47.3
1894	30	906	0.0331	30.2
1895	22	583	0.0377	26.5
1896	14	741	0.0189	52.9
1897	19	836	0.0227	44.0
1898	54	609	0.0887	11.3
1899	51	595	0.0857	11.7
1900	28	561	0.0499	20.0
1901	9	411	0.0219	45.7
1902	33	465	0.0710	14.1
1903	19	565	0.0336	29.7
1904	12	387	0.0310	32.3
1905	27	607	0.0445	22.5
1906	9	295	0.0305	32.8
1907	19	467	0.0407	24.6
1908	9	541	0.0166	60.1
1909	2	131	0.0153	65.5
1910	4	139	0.0288	34.8
1911	6	150	0.0400	25.0
1912	0	0	0.0000	
1913	0	102	0.0000	
1914	10	105	0.0952	10.5
Total	3,198	65,135		
Average			0.0491	20.4

stitute for baleen, caused the market to collapse in 1908, quickly dragging the industry with it. After 1914, although a few vessels cleared port as whaleships, they were in fact primarily on fur trading and freighting cruises, and only a few bowhead whales were taken commercially by ships thereafter (Bockstoe, 1986:335–339).

Because we have identified the total number of annual cruises that whalers carried out in the B-C-B fishery, we can calculate the percentage of documented cruises for the year that our data represents. Using the percentages for each year, we have estimated the total catch by simple extrapolation (Table 3). These data indicate that a total of 16,594 bowhead whales were captured by whaleships from 1849 to 1914 (Bockstoe and Botkin, 1983:116). Woodby and Botkin (1993) later estimated that the total population of bowhead whales in 1847 (the year before the discovery of the B-C-B whaling grounds) would have been approximately 20,000.

Although steamships and other technological advances could have increased the efficiency of the capture, the rapidly declining abundance of the bowhead overwhelmed the catch efficiency, so that CPUE is much lower after 1880 than before. Steam-auxiliary powered vessels allowed the whalers to pursue whales in locations and at times not previously possible, but did not lead to an increase in CPUE in comparison to the sail era (Fig. 3A and B).

Changes in Whale Distribution Over Time

Our analysis of the historical records indicates that 16,594 bowhead whales were captured during the period 1849–1914 and that the population was rapidly depleted: one-third of the total number of captures took place during the first decade of the fishery, and two-thirds—nearly 12,000 bowheads—in the first two decades (Table 1). Most of the captures took place in the Chukchi Sea and the northern Bering Sea, but a large number were also taken in the southwestern Bering Sea in the first decade of the period (Maps 5–6). Captures per ship for the seasons from 1851 to 1854 were

so poor in comparison to the returns from 1848 to 1850 (Table 1) that only a few whaleships cruised in the Bering Strait region from 1855 to 1857; instead they hunted in the Okhotsk Sea.

The Okhotsk Sea bowhead population (where, because the whales had no ice cover in the summer, they were less able to escape from the hunters) was very quickly reduced. So in 1858, lacking other significant alternatives for whale hunting in the North Pacific, the whalers returned to the B-C-B grounds to cruise there relatively successfully for the next half century, although their catches never approached the returns of the first 3 years of the fishery.

The whalers quickly learned that where they had made a large catch in one year it was unusual to have success there for 3 years or more. In 1851, for example, one captain reported seeing no whales where he had found them previously: "Where I whaled last voyage, now looks like a deserted village," he wrote (Anonymous, 1853a). And on 5 May 1852, in the southwest Bering Sea, near the coast of Kamchatka, the mate of the *Montreal* wrote: "No whales, the [whaling] ground appears as barren as the deserts of Arabia, altho [sic] we are on the very spot where last May we saw whales in abundance" (*Montreal*, 1852).

Several possible explanations for this phenomenon include 1) geographical isolation, 2) learning behavior, and 3) food distribution.

Geographical Isolation

The whales were geographically isolated, and each geographic group was essentially extinguished by the whaleships, which then did not have a large catch until they found another group.

Learning Behavior

The bowheads may have quickly adapted to the new hunting threat, both learning to avoid nearby whaling ships and moving to areas where whaling was not occurring. Many anecdotal accounts support this possibility. In 1849, the first year that the whaling fleet cruised in the Bering Strait region, one whaler wrote that the whales "appear to be very shy indeed" (*Omega*, 1849). Another

wrote in 1850, "The whales appear very shy. They don't like cold iron" (Bockstoce, 1986:101). And in 1852 one captain reported that the bowhead was "no longer the slow and sluggish beast we first found him. Particularly in the latter part of the season, they are very shy" (Anonymous, 1853b).

The historical records also indicate that the bowheads quickly learned a number of responses to avoid capture, including developing the ability to distinguish between background sounds and sounds made by whale hunters. For example, one whaling captain wrote: "If a bowhead is near an ice pack, and a chunk of melting berg suddenly drops into the water with a loud splash, it does not disturb the whale, but let a whaleboat, proceeding ever so cautiously toward [the whale], strike a floating piece of ice in his neighborhood, and ... [it] vanishes" (Bockstoce, 1986:100-102).

Hartson Bodfish, a successful whaling captain in the latter years of the fishery, described one bowhead's skill at avoiding capture: The bowhead "came right toward us, and it looked like a certain shot for the [harpooner]. [The bowhead] came up until the [harpooner] might have struck him ... then the bowhead stopped ... Then that whale started swimming backward! He backed straight away until he was out of danger, turned and disappeared ... On another occasion ... just as the [harpooner] raised his iron, the whale jumped backward and sank like a stone. He moved so suddenly and violently that the boat dropped into the hole he had left in the water and was nearly swamped" (Bodfish, 1936:94).

And there are other reports that when a whale sensed a whaleboat nearby, its body would stiffen slightly and then the bowhead would jump backward, roll sideways, or sink (Bockstoce, 1986:101). Recent research (Koski et al., 1988; Richardson, 1999) indicates that bowheads may react to foreign noises from as far as 35 km away.

Food Distribution

Whales may also have moved from one part of their range because of changes in the distribution of their food (see,

for instance, Hunt et al., 2002), which were in turn the result of variations in climate and currents, including upwellings, a part of the natural variation in the distribution and abundance of all forms of life (Botkin, 1990). Some anecdotal evidence supports this speculation. In 1853 one whaler wrote: "The crop of 'whale feed' in the northern seas is sometimes diminished, and sometimes entirely destroyed. This may be occasioned by the ice remaining very late and entirely covering the waters beneath which the [plankton] exist. This undoubtedly causes the difference in the movements of the Polar whale, their different route, and positions in feeding at different stations. During the two seasons [1851 and 1852] in which I cruised in the Arctic, with few exceptions, the movements of the Polar whale have been entirely different. In the localities where the great numbers were found last season, they were scarce during the first and vice versa. This is one reason why some ships could not take more oil. The instinct of the whale teaches him where the best 'feed' is to be found and he goes there" (Anonymous, 1853c).

Bimonthly Location of Captures

In our search for the possible existence of subpopulations within the B-C-B bowhead stock we have so far considered how the location of captures changed over the years, but it is equally important to examine seasonal capture locations from 1849 to 1914 (Maps 19-31). Capture changed with the season partially in response to whale migration patterns—patterns apparent in the historical logbooks and in modern observations. Some bowheads moved north annually through Bering Strait, while others remained in the Gulf of Anadyr and the northwestern Bering Sea. Captain Thomas Roys, the discoverer of the Bering Strait whaling grounds, wrote: "I have known whales to hold their position between St. Lawrence Island and the main [the Chukchi Peninsula] for weeks together" while feeding (Roys, n.d.). Another whaler wrote in 1853: "Some [bowheads] exhibit a great anxiety and haste to move north [through Bering Strait], although

others linger further south during the season" (Anonymous, 1853c).

Some whalemens reported that the whales passed north through Bering Strait in the spring in two groups: small whales in June and larger whales—mostly cows with calves—in July (New Bedford Whaling Museum, 1858; *John P. West*, 1866). Earlier in the spring, other segments of the bowhead population may have moved north through Bering Strait before the whalemens, impeded in their progress northward by pack ice, were able to reach those waters.

The whalemens' anecdotal accounts accord reasonably well with recent studies of bowheads (Ljungblad et al., 1986). Russian researchers, in collaboration with Chukotkan natives, have identified three groups of bowheads: 1) a group that remains in the Gulf of Anadyr and the waters north of St. Lawrence Island throughout the summer, 2) another that moves northward out of the Bering Sea in late March or early April and passes along the coast of northwestern Alaska in three temporally spaced "pulses" (which may be segregated by age and sex), reaching the Beaufort Sea at the end of May or early June and remaining in the eastern Beaufort Sea and Amundsen Gulf until late August or early September, and 3) a third group that moves north out of the Bering Sea in mid May.

This third group is found on the north coast of the Chukchi Peninsula in June and July and then is believed to move to the western Chukchi Sea and the East Siberian Sea before returning to the Bering Sea in the autumn (Moore and Reeves, 1993:336–338; Zelensky et al., 1997; Bogoslavskaya, 2003). It is the Russians' second group which would have departed from the Bering Strait region before the retreating pack ice allowed the whaleships to reach those waters.

As we noted, in the first years of the fishery whalemens captured bowheads in a surprisingly large area (from about lat. 55°N in the southwestern Bering Sea to lat. 69°N in the southern Chukchi Sea), and whales were taken in areas where few were seen again, as far south as lat. 57°30'N. For example, Edwin Coffin

(1850–53) of the ship *Vineyard* reported that large numbers of bowheads were also seen near St. Matthew Island in late August 1851, and Captain Abraham Pierce (1854) of the *Kutusoff* reported that bowheads were taken in the western part of the Gulf of Anadyr in July 1853; others were reported captured on the south shore of the Chukchi Peninsula in Holy Cross Bay (*Zaliv Kresta*) in June 1866 (Hegemann, 1890:410–412).

As the month of July progressed (Maps 24, 25), the retreating ice usually allowed the whaleships to roam throughout most of the Chukchi Sea. Although some whales were taken in the latter half of July in the Gulf of Anadyr, in the same period of time a large number were harvested in the southwestern part of the Chukchi Sea, north of the Chukchi Peninsula. As we have mentioned, this was the region that the whalemens called the "Cow Yard" near lat. 67°N, long. 171°W, where a large number of female whales were taken in 1849.

Two-thirds of the total whale kills by ships had taken place by 1869. Faced with declining catches, in the 1870's the whalemens pushed to the perimeters of the Chukchi Sea in August and even along the north coast of Alaska (Maps 26, 27). With the 1880 introduction of steam-auxiliary power, whaleships extended their hunting range even farther; by 1889 steam power allowed the fleet to reach the waters of the eastern Beaufort Sea (Maps 13–18). Some whales were taken on the north coast of Alaska, but many were captured near the Mackenzie River delta and in the waters near Cape Bathurst and in Amundsen Gulf.

By early September, even early in the fishery, many of the bowheads had left the Bering Sea (Map 28), and the whalemens encountered them along the north coast of Alaska and in the Chukchi Sea. By late September (Map 29) the pack ice of the Beaufort Sea began moving south, forcing the whaleships either to pursue the whales in the northern Chukchi Sea in the increasingly violent weather of autumn, or, after 1889, if the ships were in the Beaufort Sea, into winter quarters. Almost all non-wintering whaleships headed south by mid October (Maps 30, 31), and

those that remained only a few days longer did so at their peril, even though it was generally recognized that large numbers of bowheads could be found at that time in the dangerous waters of the "Southwest Grounds" near the northern coast of the Chukchi Peninsula (Cook, 1926:161).

Some whalemens believed that in October, as they were leaving the Chukchi Sea heading south, the bowheads were also moving south as well. In describing the loss of the whaleship *Citizen* of New Bedford at the eastern tip of Asia in Bering Strait in 1852, one whalman wrote: "It is reported that after the gale in September abated, there was a season of fine weather, and whales innumerable abounded. As winter approached, immense numbers were seen heading southward and going through the Straits into the open sea." (Anonymous, 1853d). And Charles M. Scammon, the famous whalman-scientist, noted that the native inhabitants of the Chukchi Peninsula reported that bowheads were usually seen in the bays on the south side of the peninsula in autumn, when the ice was beginning to form (Scammon, 1874:67).

The whalemens' understanding of bowhead movements in September and October corresponds reasonably well with recent observations by Russian scientists, who have identified a southward migration of bowheads out of the Chukchi Sea and through Bering Strait in the autumn. This movement appears to be associated with the arrival of sea ice. The Russians have reported that, while some whales may spend the winter in the Gulf of Anadyr, a large number are found just south of there, in the waters near Cape Navarin (about lat. 62°N) on the Asian coast (Moore and Reeves, 1993:336–344; Zelensky et al., 1997:56–57; Bogoslavskaya, 2003:237).

After the first 40 years of the fishery, bowheads were almost exclusively caught at two times of the year: either in the early spring, south of Bering Strait, or in the late summer and autumn, in the northern Chukchi and southern Beaufort seas (Bockstoe and Botkin, 1983:118, Table 2).

Table 4.—Documented captures of bowhead whales, 1849–1914, listed by month and latitude.

Latitude degree	April	May	June	July	August	Sept	Oct	Total by lat.	Cumulative total by lat.	% by lat.	Cumulative % by lat.
55					1			1	1	0.03	0.03
56		5			1		1	7	8	0.2	0.28
57	1	21	10			1		33	41	1.1	1.42
58		16	4			1		21	62	0.7	2.14
59		20	4	1				25	87	0.9	3.01
60		29	18	2	1			50	137	1.7	4.73
61	7	35	83	9	6			140	277	4.8	9.57
62	2	6	84	27	1			120	397	4.1	13.71
63	2	22	96	49	3			172	569	5.9	19.65
64	2	23	75	98	15	2		215	784	7.4	27.08
65		15	36	35	41	1	1	129	913	4.5	31.54
66		2	23	20	41	2		88	1,001	3.0	34.58
67			29	44	91	12	3	179	1,180	6.2	40.76
68			24	31	115	57	10	237	1,417	8.2	48.95
69			2	28	111	107	24	272	1,689	9.4	58.34
70		2	2	39	311	282	40	676	2,365	23.4	81.69
71				13	125	288	61	487	2,852	16.8	98.51
72					4	24	9	37	2,889	1.3	99.79
73					1	4	1	6	2,895	0.2	100.00
Total by month	14	196	490	396	868	781	150	2,895			
Cumulative total by month	14	210	700	1,096	1,964	2,745	2,895				
% by month	0.5%	6.8%	16.9%	13.7%	30.0%	27.0%	5.2%				

The total recorded numbers of bowhead captures in the B-C-B fishery, when segregated by month and by latitude (Table 4), reveal several concentrations. During the months of June, July, August, and September the whalers achieved 87.6% of their captures, and 57.0% of all captures were achieved in August and September. The latitudes of 70° and 71°N were the locations of 40.2% of the captures. We believe that the success the whalers achieved in these months and latitudes reflects the fact that many of the bowheads were captured at a time of greatest ice retreat when the whalers had the greatest access.

Today the range of the bowheads in the Bering Sea (Brueggeman, 1982; Rugh et al., 2003) is probably smaller than it was before the beginning of commercial exploitation. For example, Moore and Reeves (1993:315–319) report: "Much of the Bering Sea bowhead stock overwinters in polynyas and along the edges of the pack ice in the western and central Bering Sea Scattered sightings along the southern margin of the pack ice from approximately Cape Navarin, Siberia [near lat. 62°N], to south of Nunivak Island, Alaska [roughly lat. 60°N], suggest that bowheads are widely distributed along the boundary of the ice front. In years of

extensive ice cover bowheads can occur as far south as the Pribilof Islands, and . . . [sightings have been reported] as far south as Cape Kronotsky [about lat. 54°45'N] along the Kamchatka coast. Recent winter sightings come mainly from aerial and shipboard surveys Most whales were seen along the ice edges and in polynyas in the pack ice near St. Matthew Island and St. Lawrence Island, and in the northern Gulf of Anadyr, with only a few seen outside these areas."

Did Separate Populations Exist Within the Stock?

Recently scientists have attempted to identify genetic distinctions among various groups of B-C-B bowhead whales, but their results have been controversial and ambiguous. The strongest genetic evidence that suggests any possibility of the existence of subpopulations derives from comparisons at twelve loci in DNA collected from 207 bowhead whales that were landed at nine geographic sites over 21 years in the B-C-B (Givens et al.⁸). These data contain considerable ambiguity, in part because of the small sample size consisting of unrepresentative whales, and in part because of "potentially unreliable genetic loci." Although Givens et al. concluded that

there is "some evidence of possible genetic subdivision," they also wrote that "as yet, it is impossible to determine if observed differences among groups are attributable to 1) a single stock exhibiting generational gene shift, 2) a sub-stock harvested around St. Lawrence Island, 3) two stocks having different temporal migration patterns past Barrow," or "some combination of the above" (Givens et al.⁸). The Scientific Committee of the International Whaling Commission agrees that the data from both nuclear and mitochondrial DNA are ambiguous in regard to the possibility that distinct subpopulations may be present within the B-C-B stock.

In an earlier publication, Bockstoce and Botkin (1983:119) speculated on the composition of the B-C-B bowhead stock, writing that "it is possible that the [B-C-B] bowhead population was originally made up of several discrete subpopulations, each with its own feeding area. This is consistent with the observation that the whales appear to have been eliminated from

⁸Givens, G. H., J. W. Bickham, C. W. Matson, and I. Ozaksoy. 2004. Examination of Bering-Chukchi-Beaufort Seas bowhead whale stock structure hypotheses using microsatellite data. Paper SC/56/BRG17 submitted to the Scientific Committee of the International Whaling Commission, June.

large parts of the original feeding grounds. It is equally possible, however, that the bowheads were a single population that responded rapidly to

the presence and activities of the whaling ships, and fled areas of intensive hunting, receding farther and farther north and east to the comparatively

safer areas either near the ice or where exploitation had not yet occurred."

In the early years of the fishery, some surprisingly large whales were reported to have been taken, some yielding as many as 300 barrels of oil (Anonymous, 1868). Another bowhead, captured in 1850 by Captain Henry Taber of the bark *America*, was reported to have yielded 260 barrels (New Bedford Whaling Museum, 1907).⁹

As one would expect, the size of captured whales varied considerably. The majority of the whales yielded between 50 and 150 barrels of oil, but the smallest yielded only 37 barrels and the largest, 230 barrels. If larger whales either stayed in the Gulf of Anadyr or were the last to move north through Bering Strait, as the whalers believed they did, then these large whales would have been the ones that were most vulnerable because the retreating ice would have left them more exposed to their hunters (Table 5, Fig. 4).

Nevertheless our historical record reveals that the size of the largest whales decreased over time (Table 5): The largest bowhead that was recorded in our database was taken in 1851 (230 barrels), and, most important, bowheads that were recorded as yielding more than 200 barrels were obtained only during the 1850's. The last year that a whale with more than 160 barrels was taken was 1859, except for one 180-barrel whale that was taken in 1880. After 1870, only 3 whales were killed which yielded 130 or more barrels of oil (Fig. 4).

In our database only six whales are recorded as having yielded 200 or more barrels, and five of these were taken between lat. 63° and 64°N and long. 173° and 178°W, in the waters west and north of St. Lawrence Island (Table 5, Fig. 4). Interestingly, this places the largest whales within the region where modern DNA analysis suggests that a distinct population—which some authors refer to as the "St. Lawrence subpopulation"—might exist (Givens et al.⁸). If a genetically distinct "St. Lawrence subpopulation" (Givens et

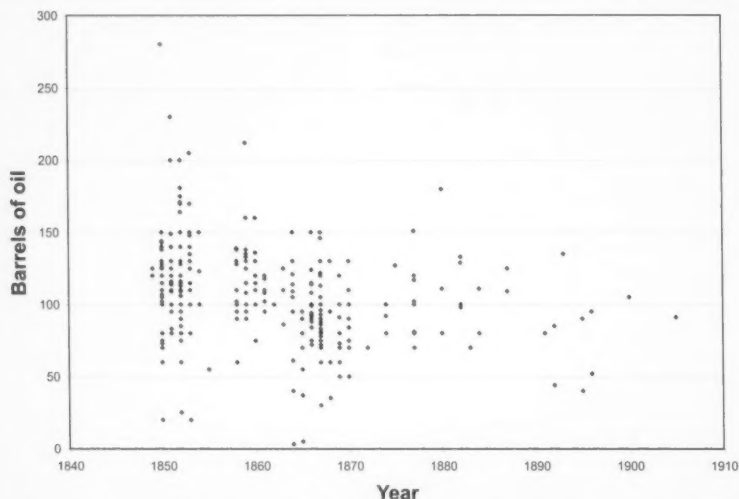


Figure 4.—Recorded barrels of oil, 1849–1914, obtained from those captures which were documented in our database. These data are the best available measure of the size of the whales. Not many logbooks and journals contain records of the amount of oil yielded by individual whales. In our database, of the 2,985 whales captured, the yield of oil was recorded for 390 (13%) bowheads. After about 1880, the focus of the fishery increasingly shifted to acquiring baleen in preference to oil; hence, by then the yield of oil per whale was rarely recorded. A barrel of whale oil was measured as 31.5 U.S. gallons (119.24 l). Note: The digitized records showed two whales with less than 10 barrels, one at 3 and one at 5. We assume these are recording errors by those who did the digitizing and have omitted these.

Table 5.—Largest recorded oil yields from individual bowheads, 1849–1914.

Rank	Oil (barrels)	Year captured	Month	Day	Lat deg	Lat min	Long deg	Long min
1	280	1850	7	9	64	0	175	40
2	280	1850	8	14	69	40	171	20
3	230	1851	6	19	63	25	179	55
4	212	1859	8	18	69	30	165	30
5	205	1853	7	12	63	33	178	0
6	200	1851	6	19	63	40	178	10
7	200	1852	7	17	64	43	178	0
8	200	1852	8	1	64	3	173	10
9	181	1852	5	20	58	0	169	0
10	180	1880	8	15	70	36	162	25
11	175	1852	4	28	57	30	165	20
12	175	1852	7	4	61	49	179	56
13	171	1852	5	9	57	25	166	30
14	170	1852	7	28	63	45	174	0
15	170	1852	8	8	68	18	167	10
16	170	1853	8	4	65	10	171	30
17	164	1852	5	14	56	45	164	30
18	160	1859	7	26	69	10	166	30
19	160	1860	7	15	64	20	171	30
20	151	1877	6	15	60	45	175	0
21	150	1866	7	30	70	50	176	30
22	150	1866	7	31	70	40	176	40
23	150	1867	6	24	67	55	171	30
24	150	1867	7	26	68	30	173	30
25	150	1867	9	17	68	50	173	20

⁹Logbooks and journals from these cruises have apparently not survived.

al.⁸) did exist, within the B-C-B stock, in the Gulf of Anadyr and nearby waters, this population would have amounted to only a small percentage of the total bowhead numbers. Of the total of 3,198 documented bowhead captures in our historical data sample, only 330 (10.3%) were taken within the region that would be considered to be the habitat of this putative subpopulation.

The history of the catch is not inconsistent with the existence of multiple subpopulations, but it does suggest that it is unlikely. The longevity and long distances traveled also argue against a distinct population. A few bowheads that were captured near Point Barrow between 1981 and 1993 were found to carry fragments of native whaling equipment, none of which is thought to have been employed by native hunters after about 1880. Recently a stone weapon point was found in a bowhead that was taken near Point Barrow. The age of the whale was judged to be greater than 120 years, an estimate that was based on the number of corpora in the ovaries (George¹⁰), and other bowheads were judged to live longer than 100 years via studies of the eye lens (George et al., 1999).

Because many bowheads do annually migrate long distances, and because some appear to live longer than a century, it seems likely that whales from the entire region shown in Map 4 would have encountered one another at some time during their lifetimes. Only a few such encounters are necessary to lead to mixing of DNA, suggesting that the entire B-C-B population of bowhead whales would function as a single genetic unit. The primary reason that such a mixing might not take place might be that bowheads from one region, for behavioral reasons alone, did not breed with those of a far distant region, but there is no evidence to support this possibility (IWC, 2005:19–22).

We believe that 1) the existing DNA analysis is ambiguous in itself, and

consequently further investigation will be required to determine whether the bowhead stock comprises genetically distinct populations, and 2) geographic patterns exist in the historical dataset, but they require further analyses to determine what may be implied about separate populations. Among the possibilities are: examination of the geographic distribution of the largest whales (in terms of barrels of oil) to determine if such whales occurred in specific geographic regions; statistical analyses of environmental, geographic, and ship location variables to learn which are most strongly correlated with whale capture over years and seasons.

Additional analysis of the historical data could help resolve the controversy over genetically distinct populations. In particular, more formal geostatistical analysis is needed to determine whether there were geographically distinct clusters of bowheads. These could be combined with modern observations of the bowheads' locations. There is now a sufficiently long time-series of modern scientific observations of the bowhead whale to provide the basis for comparison of abundance and distribution of this species during the late 20th century–early 21st century period and the commercial whaling era.

As more DNA data become available, and as geostatistical analysis is conducted on the historical data, cooperation between us and those doing DNA analysis will quite likely lead to new insights. Among other benefits, the historical data could help guide DNA sampling. For example, the quantitative historical data, along with comments by the whalers in their logbooks, can help in answering questions such as: Where do the populations seem to have been extirpated after the first commercial hunt? Would these locations be a good place to sample, assuming the whales have, by now, returned?

Conclusions

We have extracted, digitized, and analyzed historical data about the B-C-B stock of bowhead whales from the logbooks of whaling ships during the ship-based whaling period, from 1849

to 1914. We located complete records of 516 annual cruises—19% of the total number of cruises—which provided more than 65,000 days of observation. These data include, among other information, the date and geographical position of the vessel, the number of bowhead whales seen, killed, and captured, and often the wind's direction and velocity, as well as the visibility and ice coverage. In these records, a total of 2,318 whales were captured, and in some cases the yield in barrels of oil or pounds of baleen—estimators of whale size—are given.

We used these records to consider the geographic distribution of the bowhead whale, noting changes in catch over time and with season. Recently, DNA analyses have been used to try to determine whether today's B-C-B bowhead stock may comprise two or more genetically significant populations. To date, the DNA analyses are ambiguous in this regard. Our goal was to investigate whether the historical records of the bowheads' geographic distribution demonstrates concentrations of whales that could be considered separate populations, or at least were consistent with the existence of such populations.

The locations where the bowheads were captured show geographic patterns, both over the history of the fishery and between annual seasons. At the beginning of the commercial fishery bowheads were taken farther west and south than ever after, and there are other areas where the whales were found for a short while, but then not found again for a number of years. One might speculate that the whales in such areas became locally extinct and therefore constituted distinct populations. Nevertheless, recently discovered evidence, both physiological and archaeological, indicates that bowheads can live more than a century, and we know that whales are capable of migrating more than 1,000 miles during a year. Therefore, it appears highly likely that individual whales could travel throughout the entire range during their lifetime and that whales could breed throughout the entire population. The only factor that might prevent such migration and therefore contribute to

¹⁰George, J. C. Department of Wildlife Management, North Slope Borough, P.O. Box 69, Barrow, AK 99723. Personal commun., 10 Jan. 2006.

the existence of separate populations within the B-C-B stock is a behavioral pattern that is unknown at present.

Between seasons, bowhead whales seem to consist of three, or perhaps more, migratory groups. If the whales only breed within their own group, then the species could consist of genetically distinct units, the most likely of which are those that do not migrate at all. But, the seasonal groupings appear to be related more to size and age than to any other known factor, which itself argues against the possible existence of genetically distinct populations within the B-C-B bowhead stock.

A final distinction of interest is that the historical data suggests the possibility of a geographical concentration of the largest whales, and if so, possibly in the region where DNA evidence may give the most credence to the existence of a subpopulation.

Although these factors are not inconsistent with the possibility of the existence of genetically distinct populations, none provide definitive evidence—or even likely support—for the existence of such populations.

The geographic clustering of the bowheads is sufficiently apparent in the historical data to justify geostatistical analysis, which has not yet been done, but which could be of value to better determine the likelihood of distinct populations, and which, therefore, could be of consequence for the conservation and management of this species.

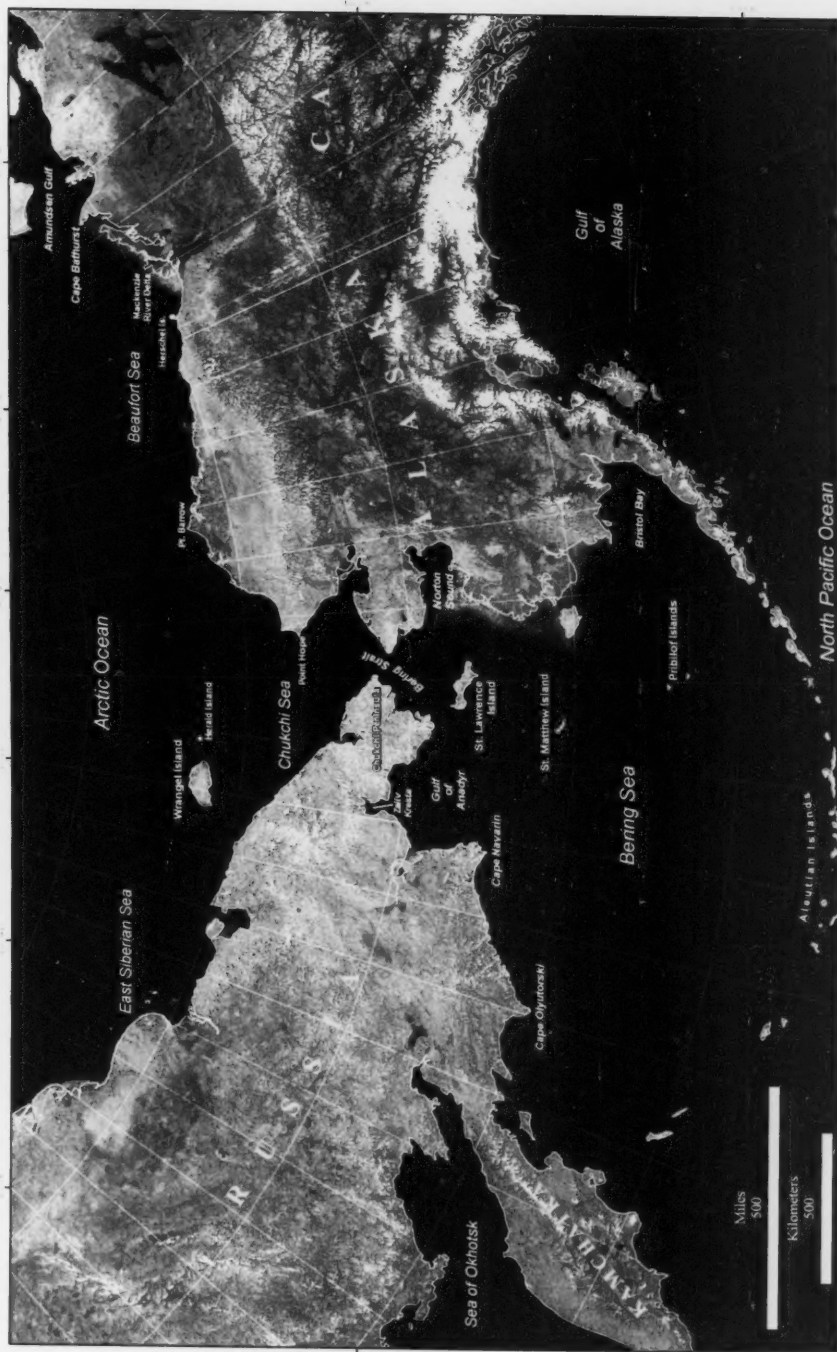
Acknowledgments

We are grateful for the financial assistance provided through the North Slope Borough ECHO Project and to its partners: The New Bedford Whaling Museum, the New Bedford Oceanarium, the Peabody Essex Museum, the Bishop Museum, and the Alaska Native Heritage Center. Patty Smith and Pearl Brower were particularly helpful in getting the grant funding in place. The North Slope Borough Department of Wildlife Management provided considerable in-kind logistical support. Brian W. Collins, of GCS Research, created Maps 1–4. Several persons have been very helpful in the preparation of this report: We thank

Diana Perez Botkin, Anne Brengle, Michael Dyer, Laura Pereira, and Brian Walsh for their generous assistance. We are also grateful to Willis Hobart and two anonymous reviewers for their editorial suggestions.

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Map 1.—Northern North Pacific, Bering Sea, and Arctic Ocean, environments which include the entire range of the B-C-B bowheads.



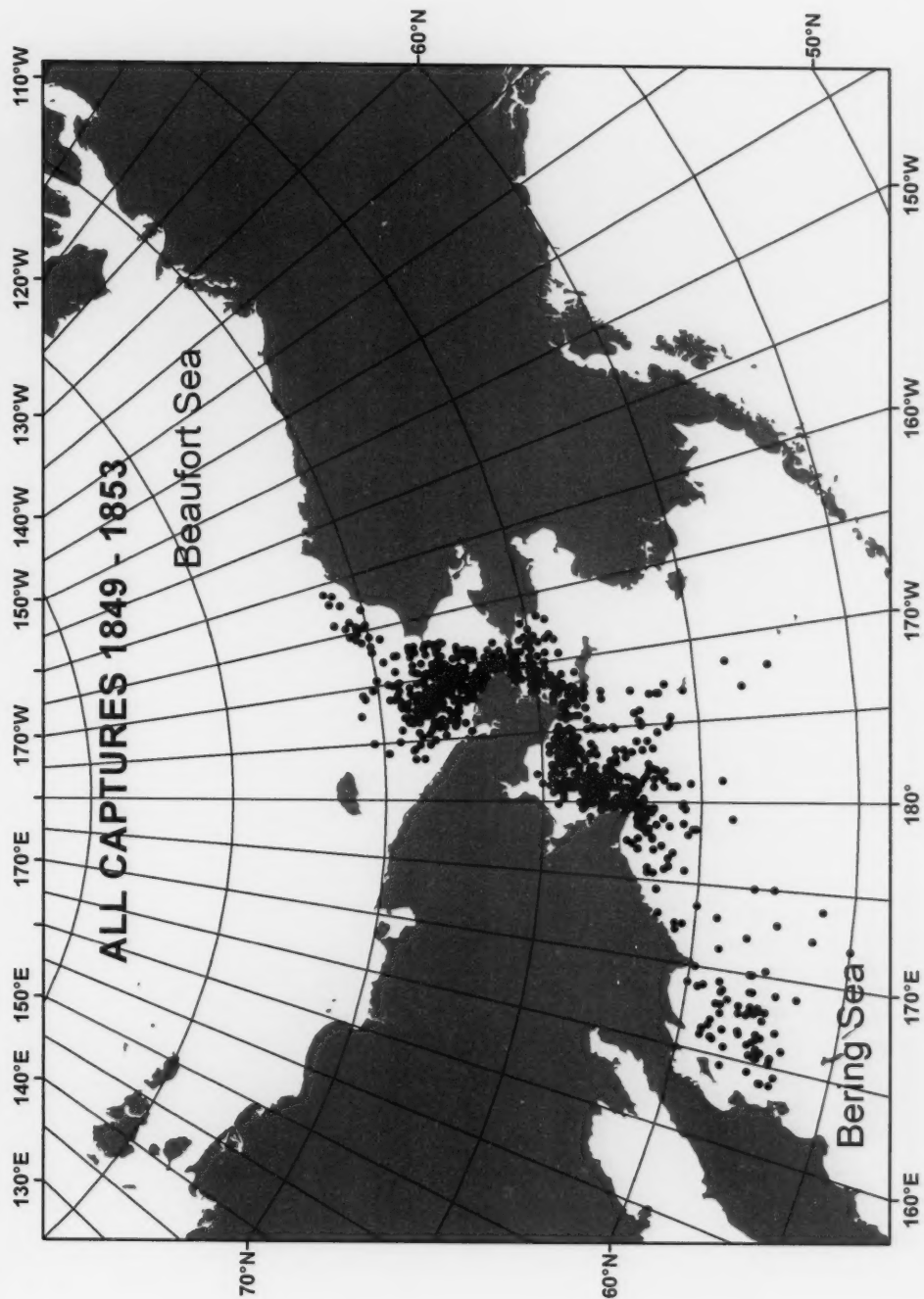
Map 2.—Total documented bowhead sightings and captures, 1849–1914 (from the database of information extracted from whalers' logbooks and journals, as are all data shown in subsequent maps). The green dots represent all recorded reports of bowheads including those that were seen only, chased and lost, and struck and lost. The red dots represent all recorded locations where bowheads were captured.

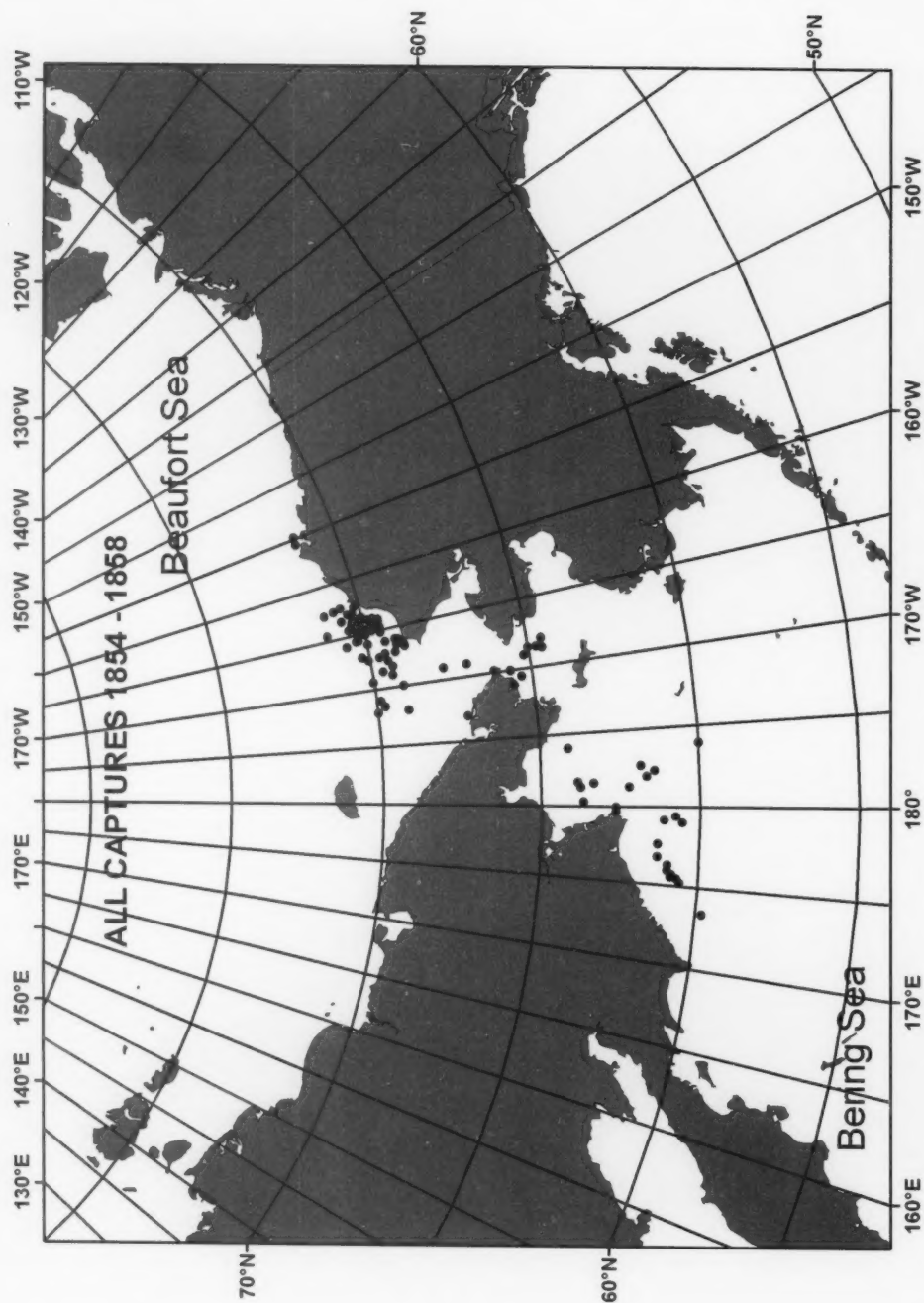


Map 3.—Total documented bowhead whale captures, by 5-year increments, 1849–1914.

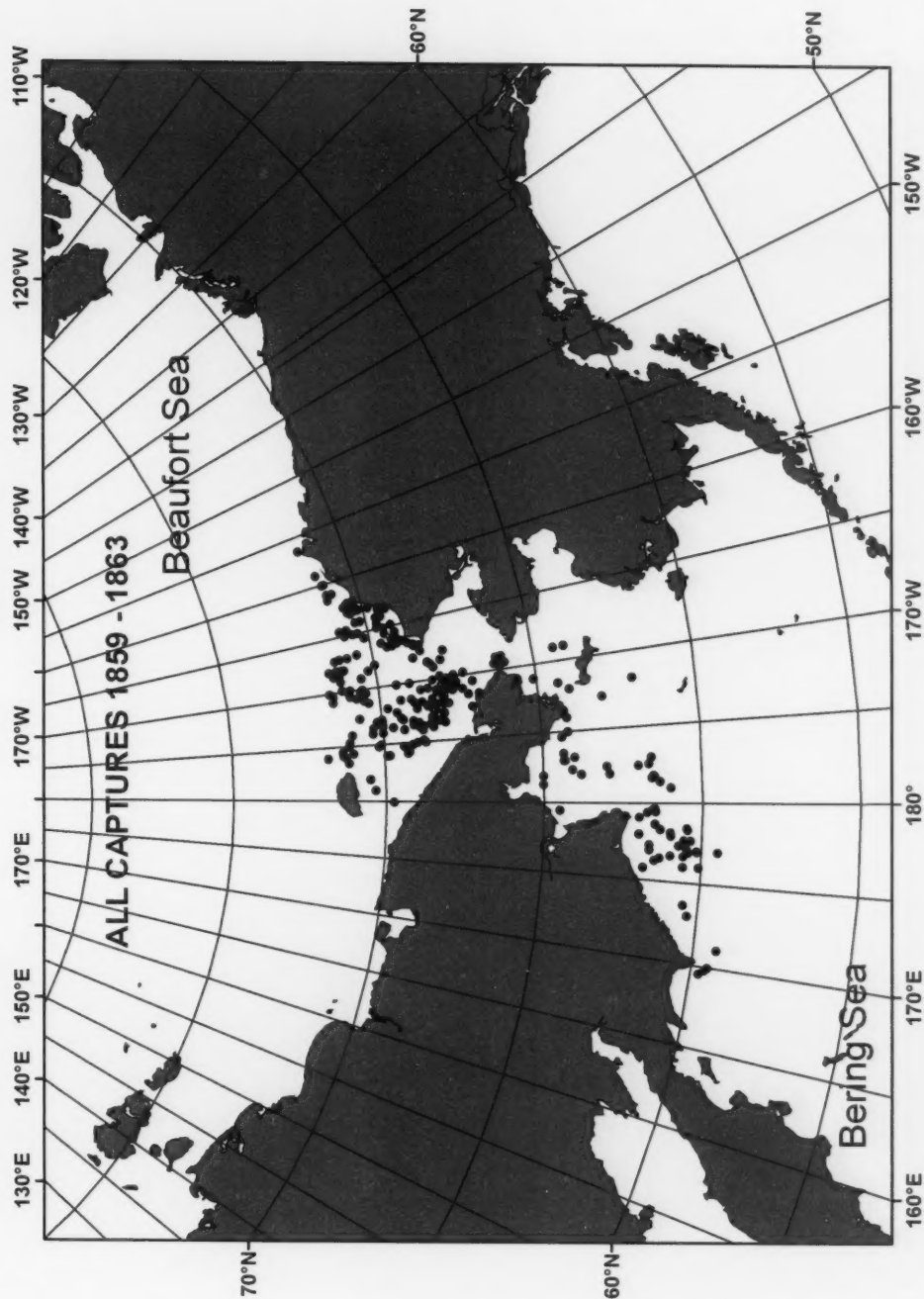


Map 4.—Total documented daily ship locations and bowhead captures, 1849–1914. The yellow dots represent all documented ship locations, which were recorded daily in the logbooks and journals. More than one ship could, of course, visit the same location, and the same ship could remain at, or revisit, a location. The red dots represent the total documented bowhead captures. This map does not indicate the intensity (number of times) that ships visited a location.

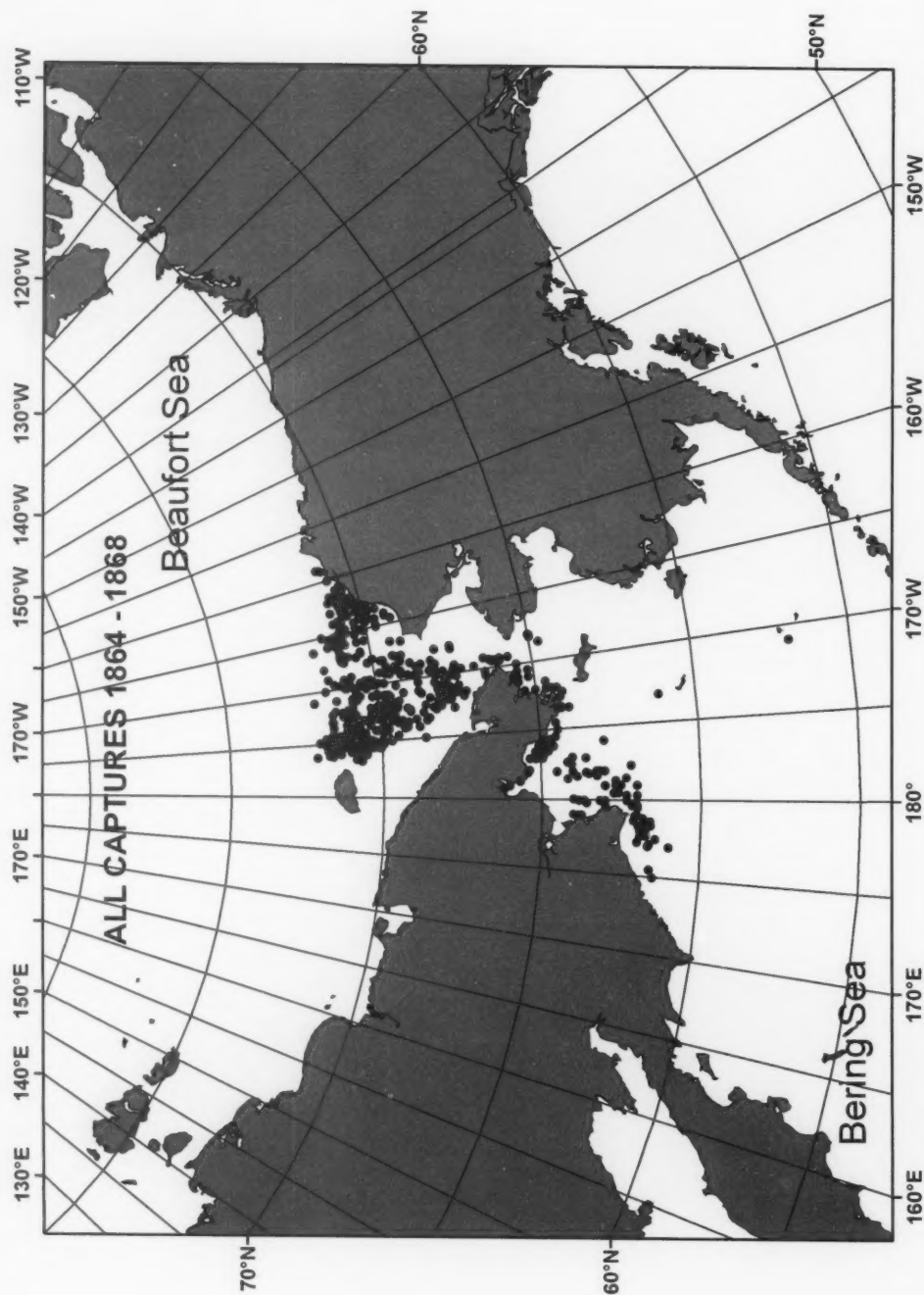




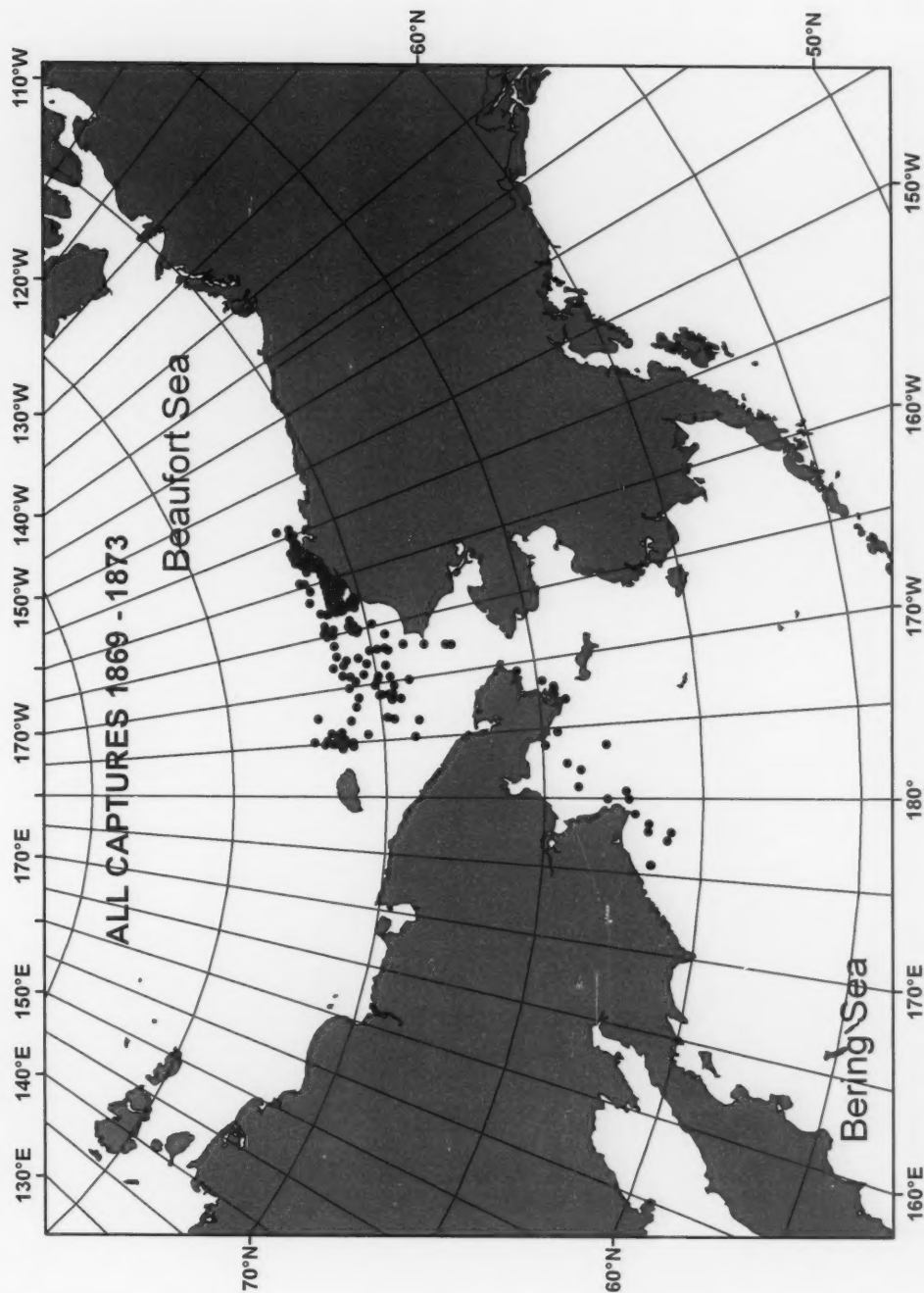
Map 6.—Documented captures of bowhead whales, 1854–1858. In the first 5 years of the fishery (1849–1853) bowheads were captured as far south as lat. 57°30'N; whereas in the second 5-year period (1854–1858) shown here, none was caught south of lat. 60°N. During this 5-year period there were 70 cruises of which 24 (20.00%) are documented in our database.



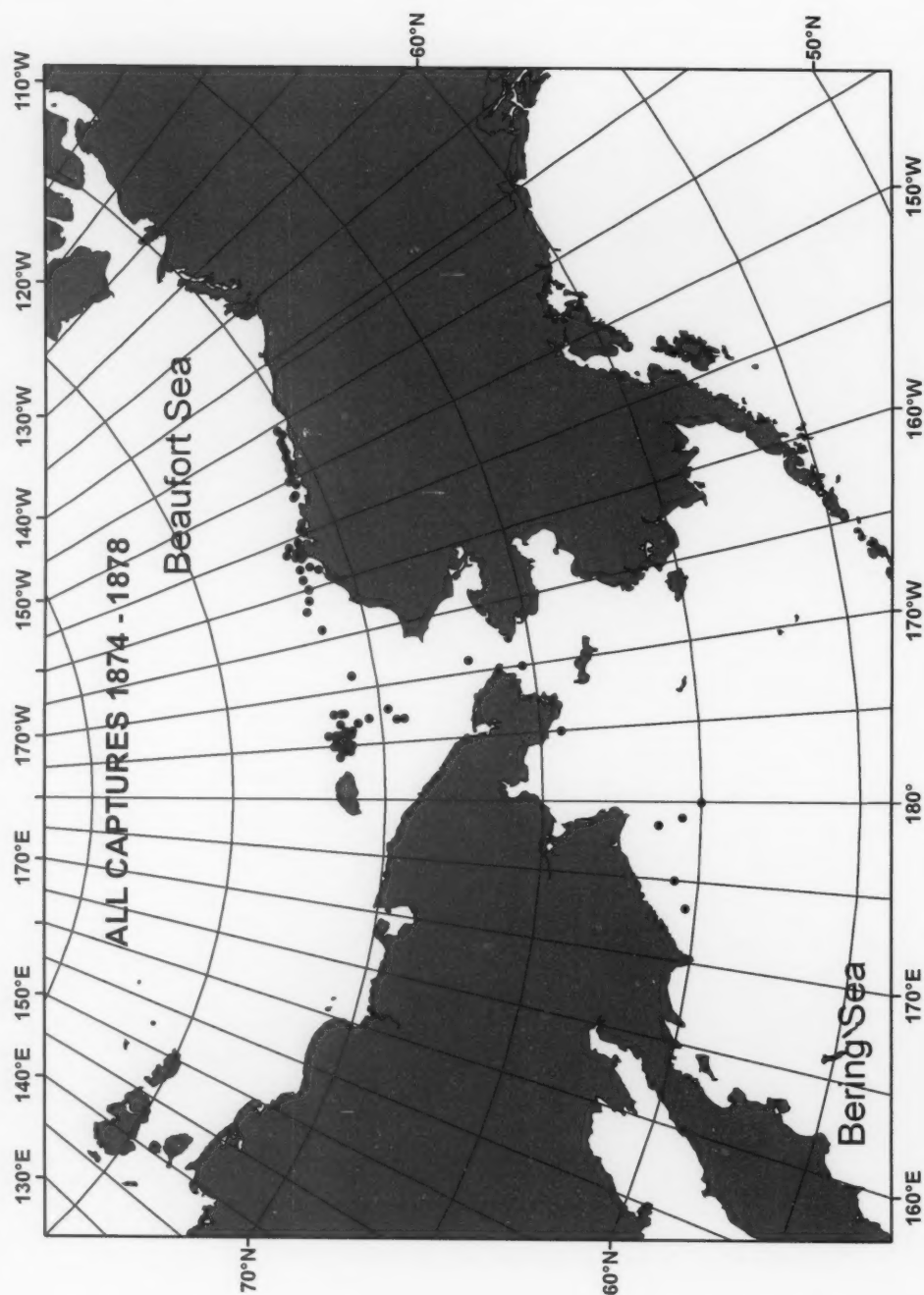
Map 7.—Documented captures of bowhead whales, 1859–63. During this 5-year period there were 235 cruises, of which 55 (23.40%) are documented in our database.



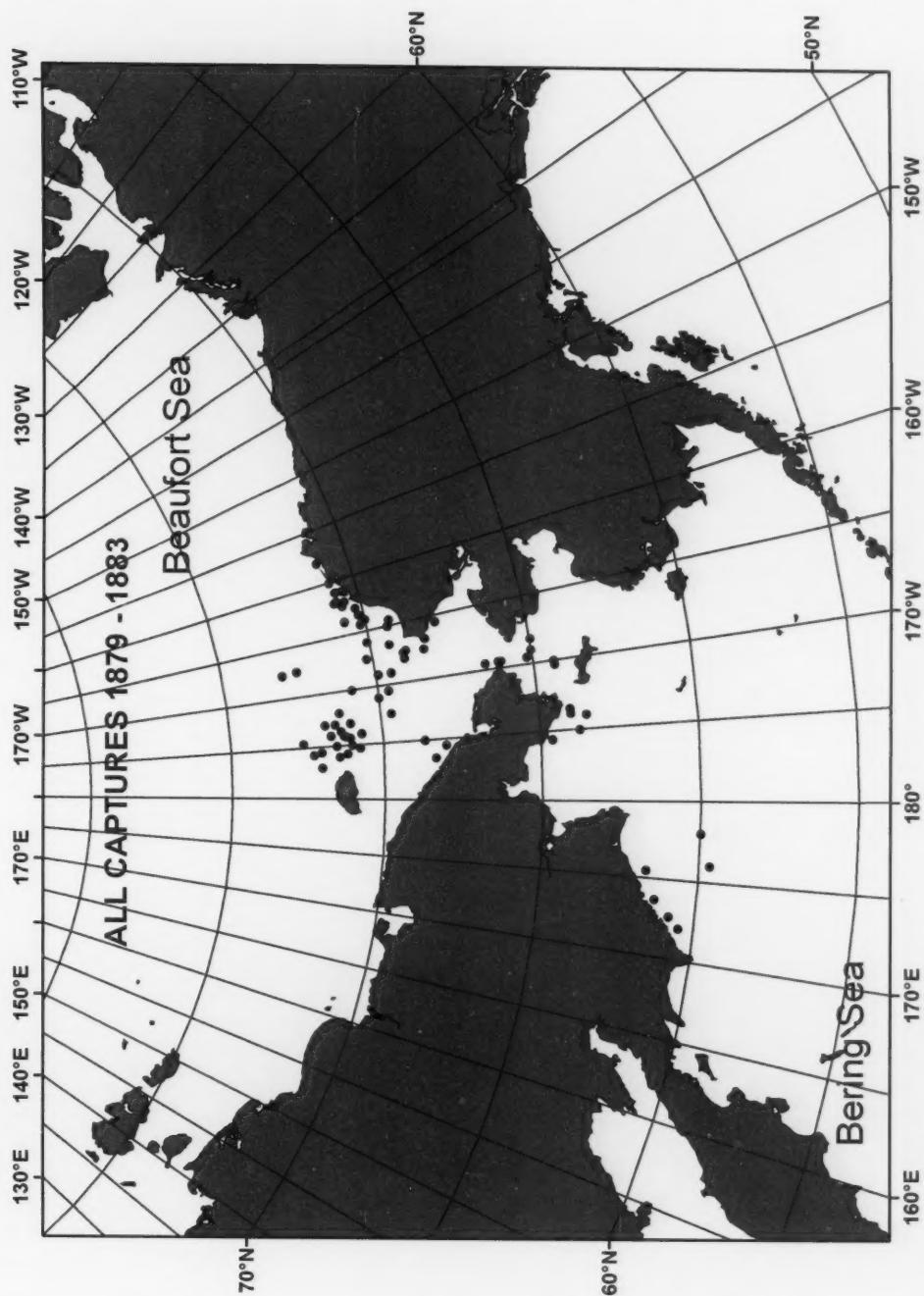
Map 8.—Documented captures of bowhead whales, 1864–68. During this 5-year period there were 388 cruises, of which 105 (27.06%) are documented in our database.



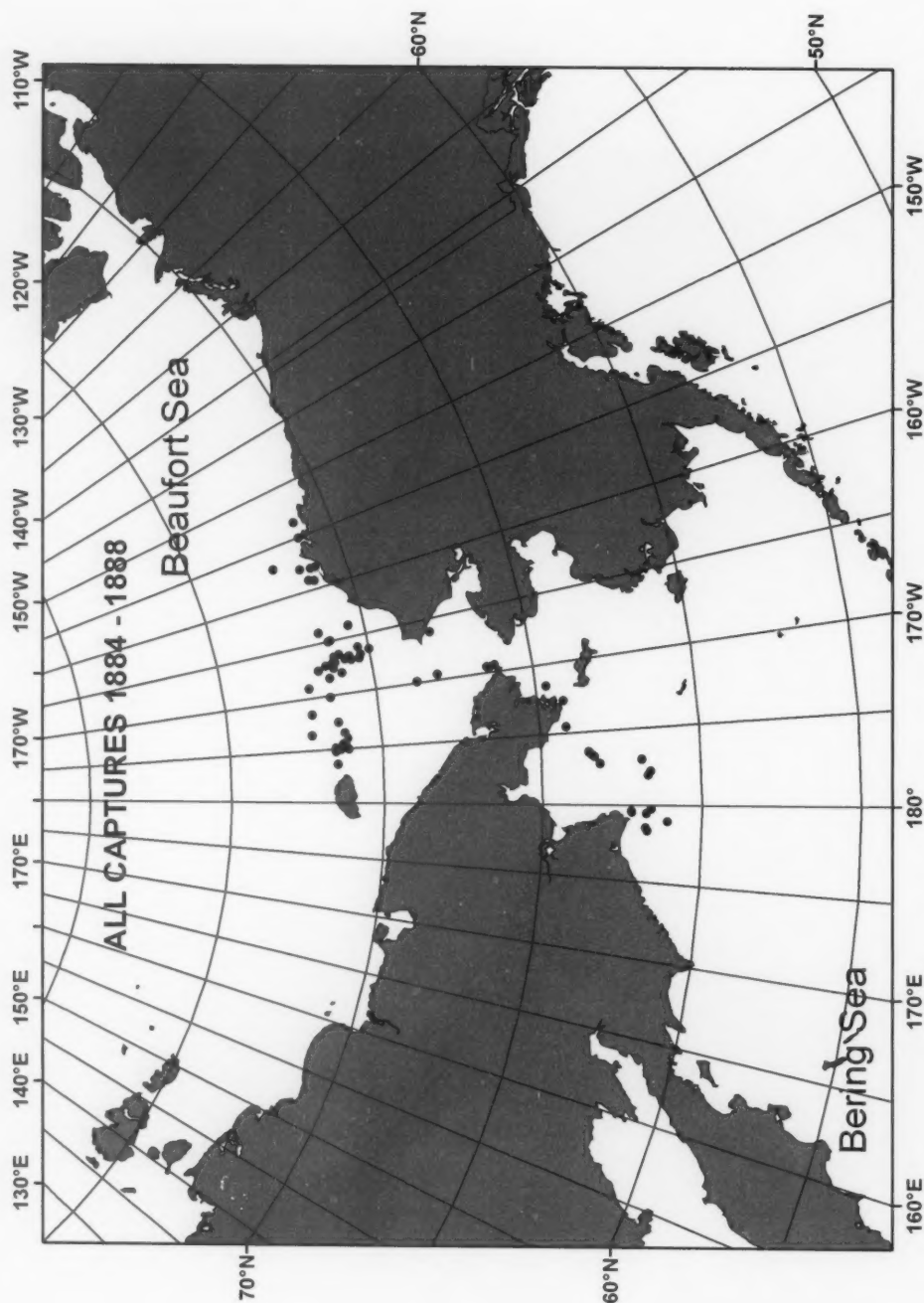
Map 9.—Documented captures of bowhead whales, 1869–73. During this 5-year period there were 210 cruises, of which 50 (23.81%) are documented in our database.



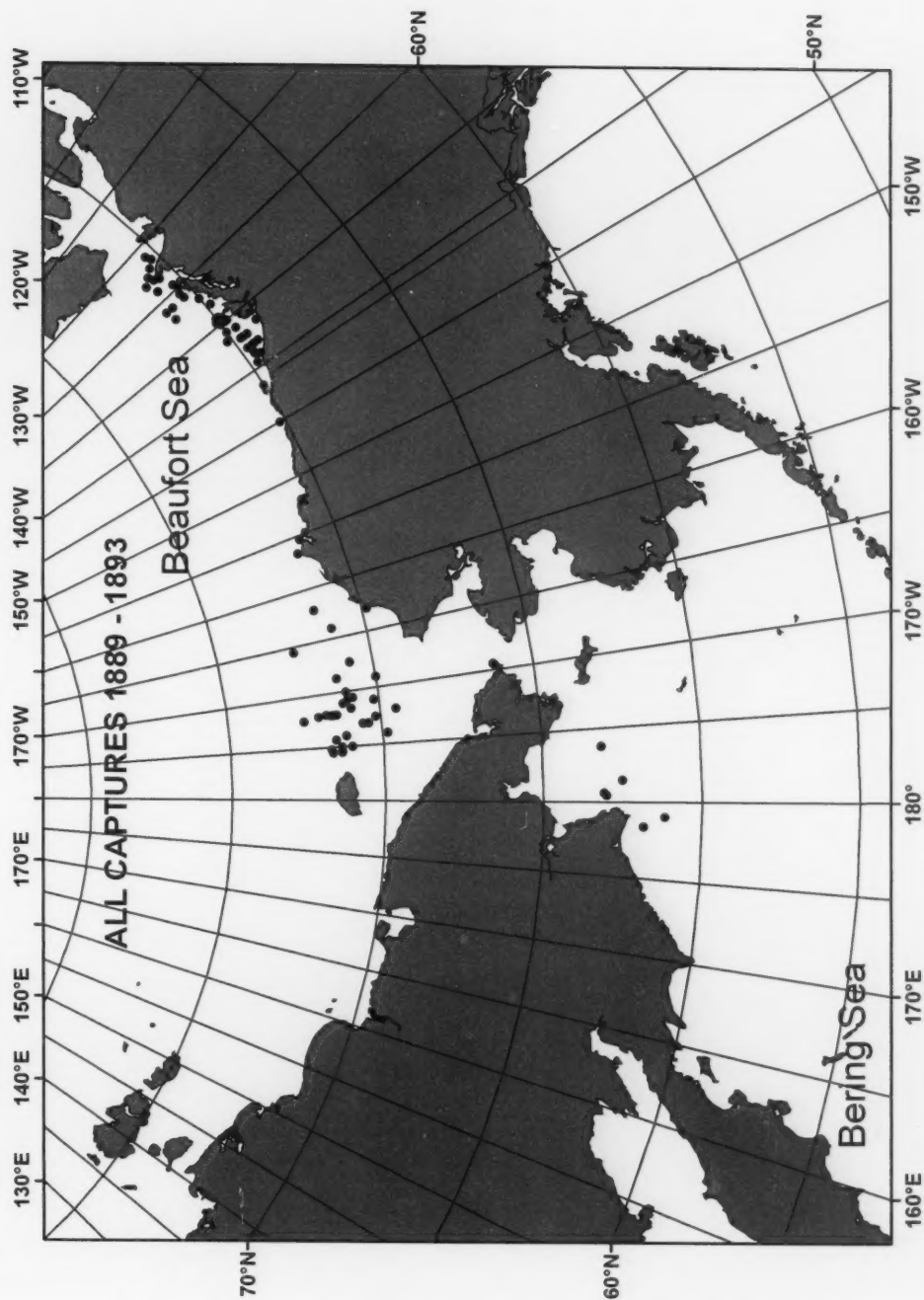
Map 10.—Documented captures of bowhead whales, 1874–78. During this 5-year period there were 105 cruises, of which 15 (14.29%) are documented in our database.



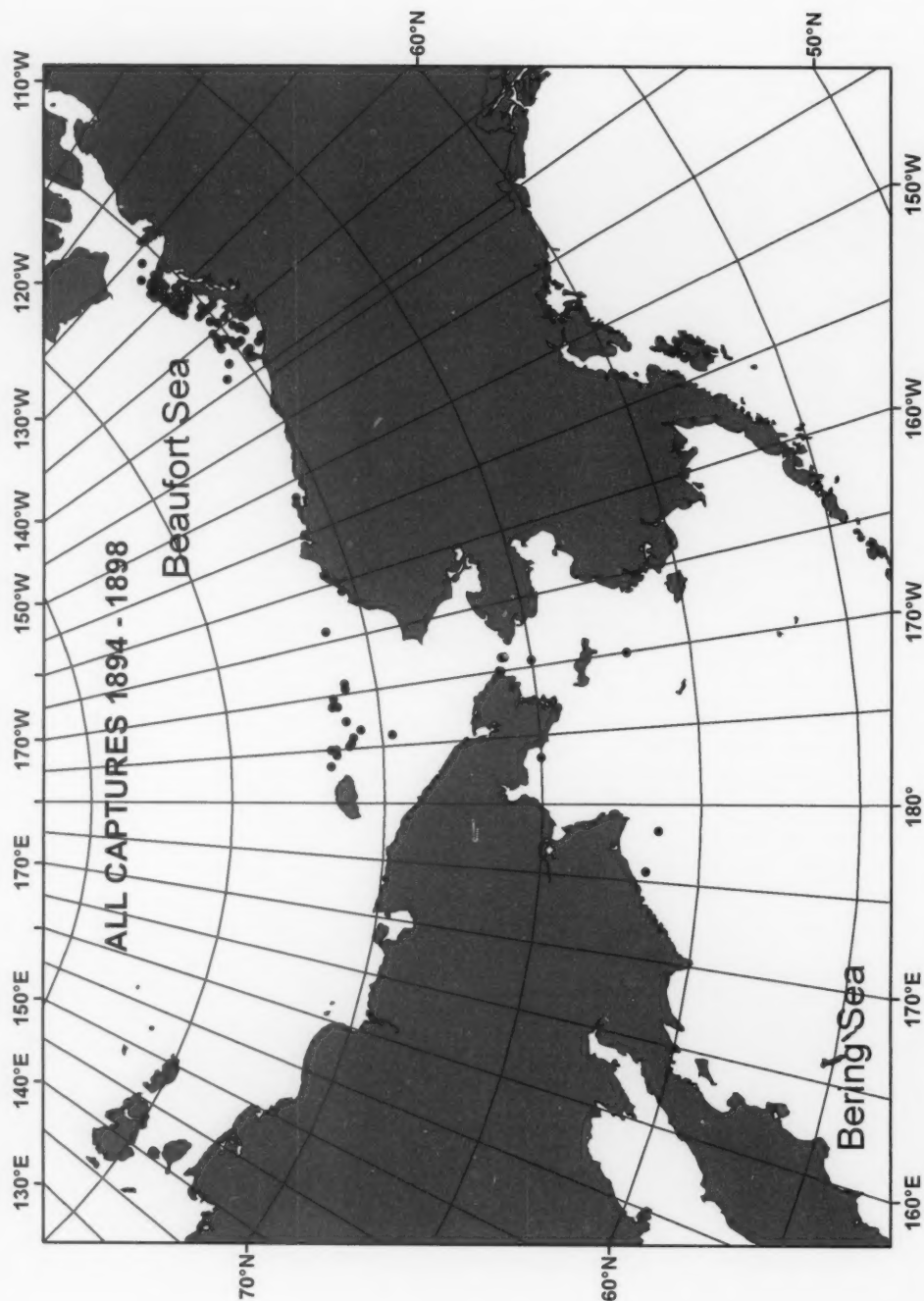
Map 11.—Documented captures of bowhead whales, 1879–83. During this 5-year period these were 145 cruises, of which 10 (6.90%) are documented in our database.



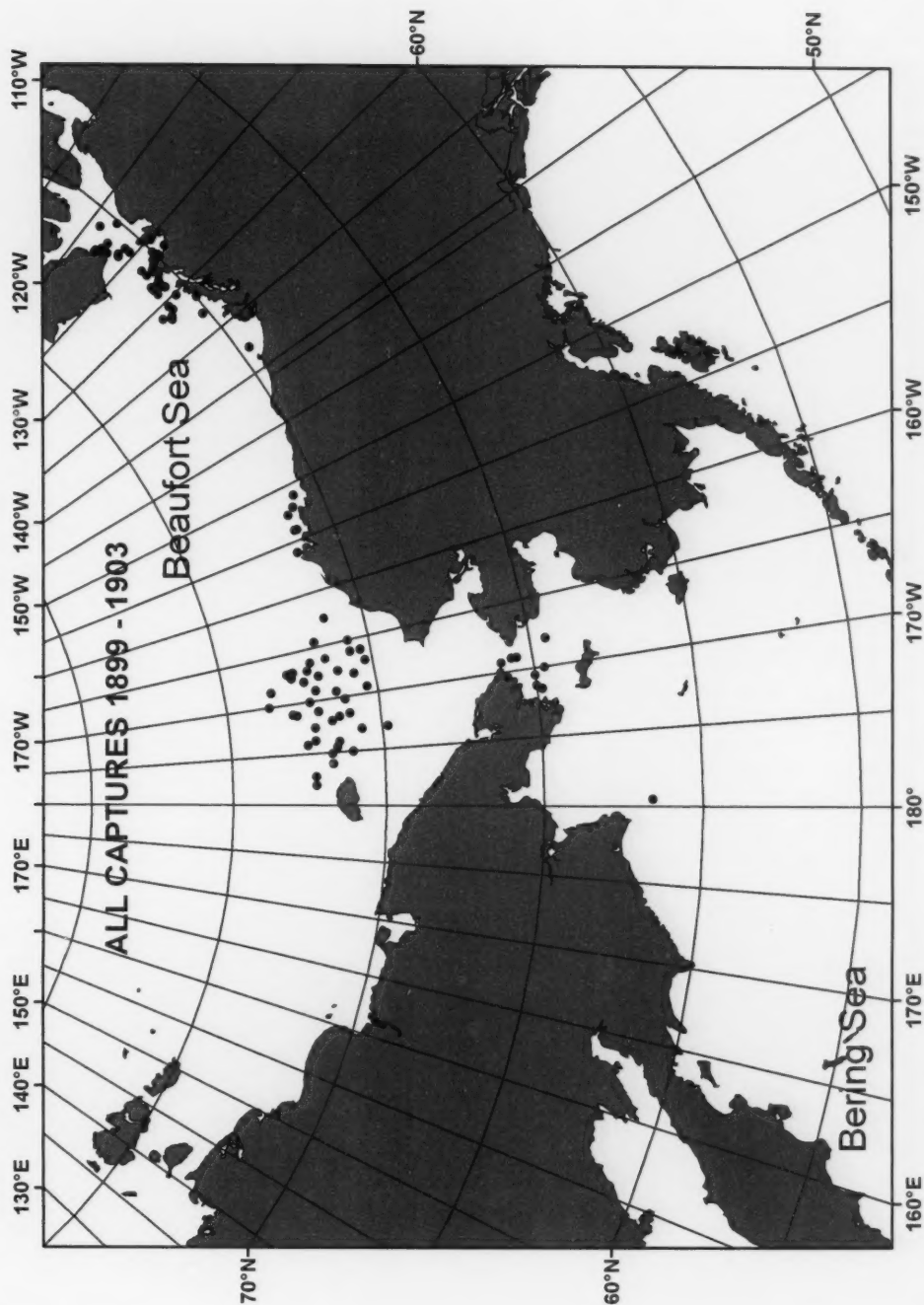
Map 12.—Documented captures of bowhead whales, 1884–88. During this 5-year period there were 195 cruises, of which 18 (9.23%) are documented in our database.



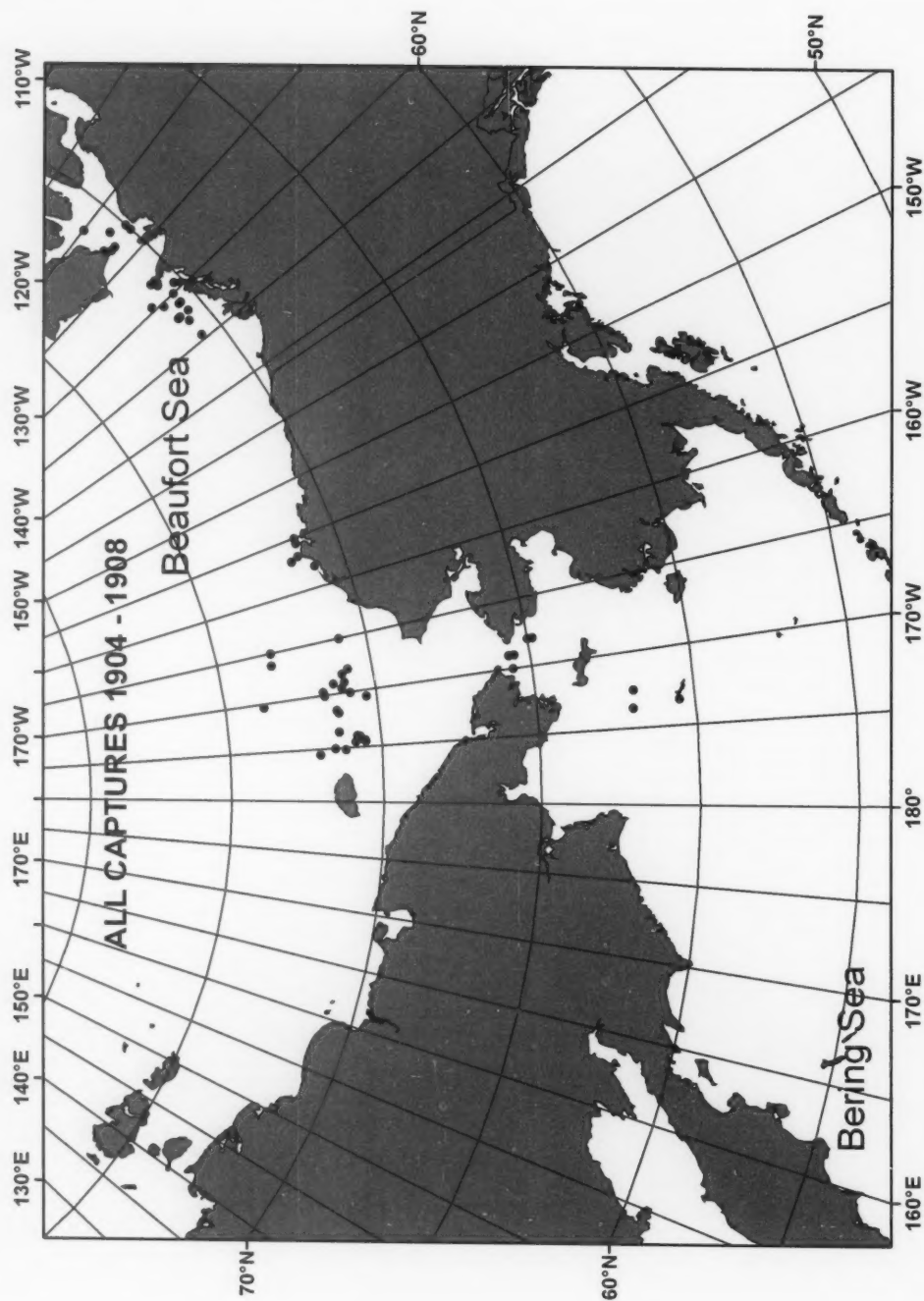
Map 13.—Documented captures of bowhead whales, 1889–93. During this 5-year period there were 208 cruises, of which 25 (12.02%) are documented in our database.



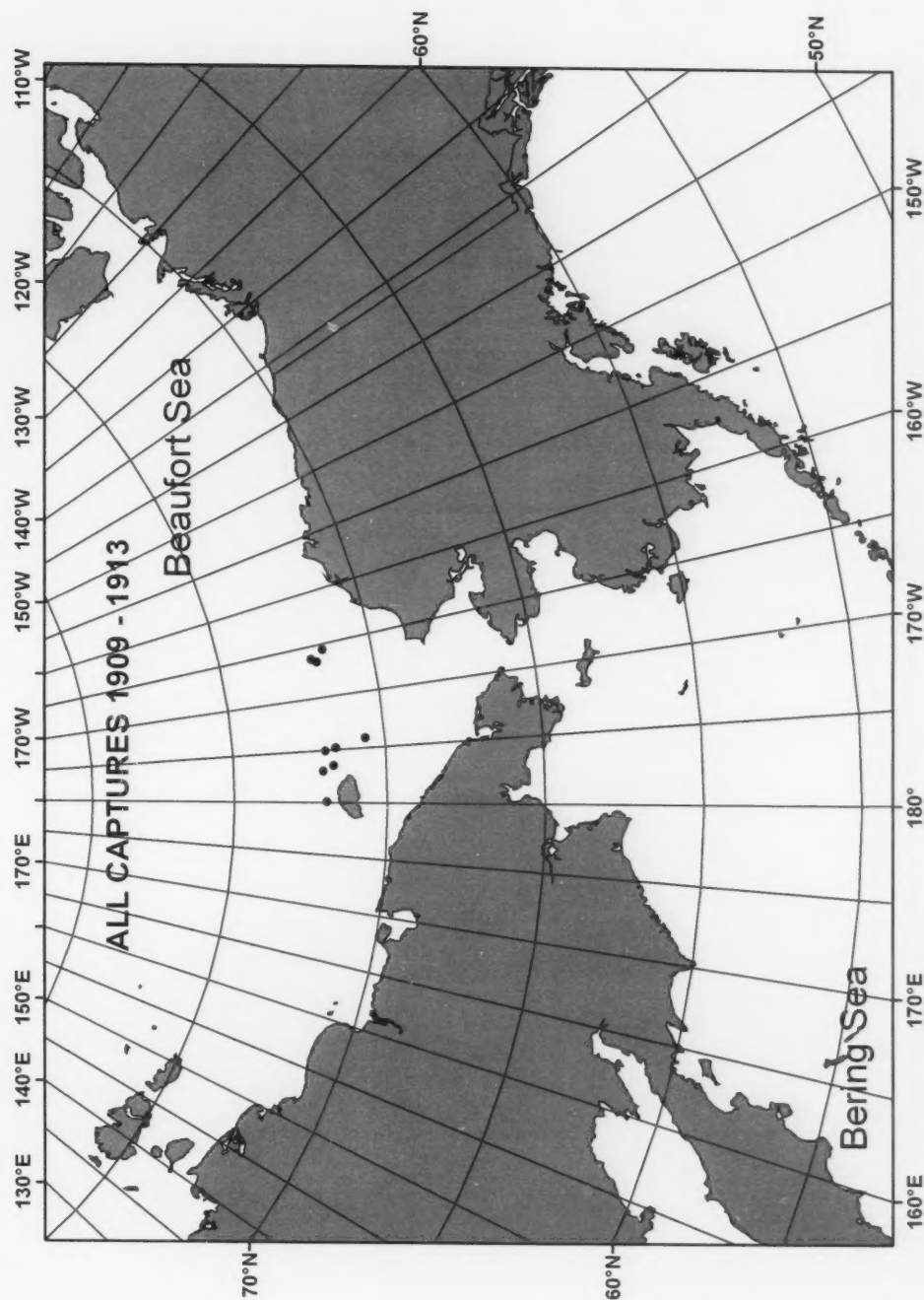
Map 14.—Documented captures of bowhead whales, 1894–98. During this 5-year period there were 131 cruises, of which 31 (23.66%) are documented in our database.



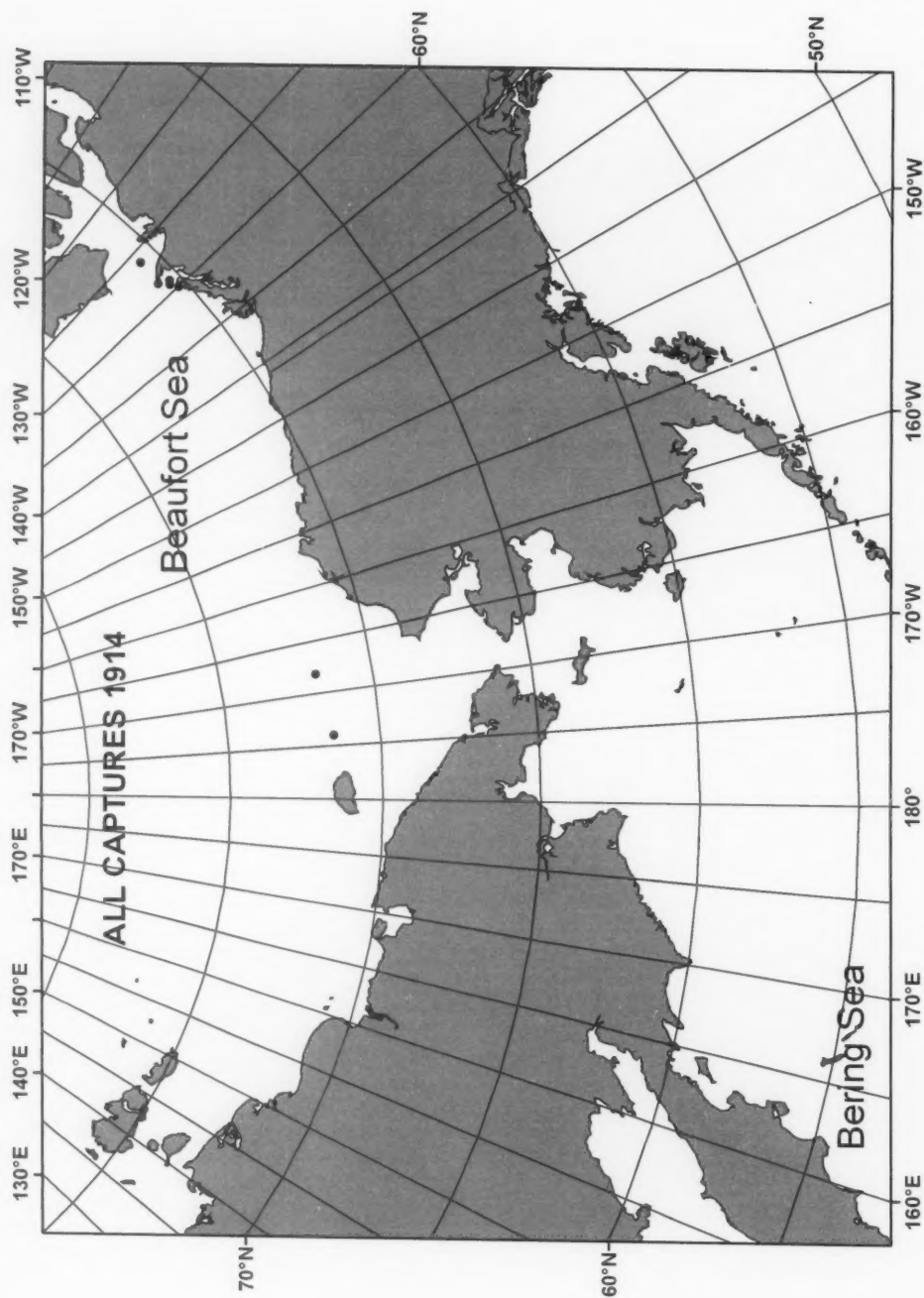
Map 15.—Documented captures of bowhead whales, 1899–1903. During this 5-year period there were 72 cruises, of which 18 (25.00%) are documented in our database.



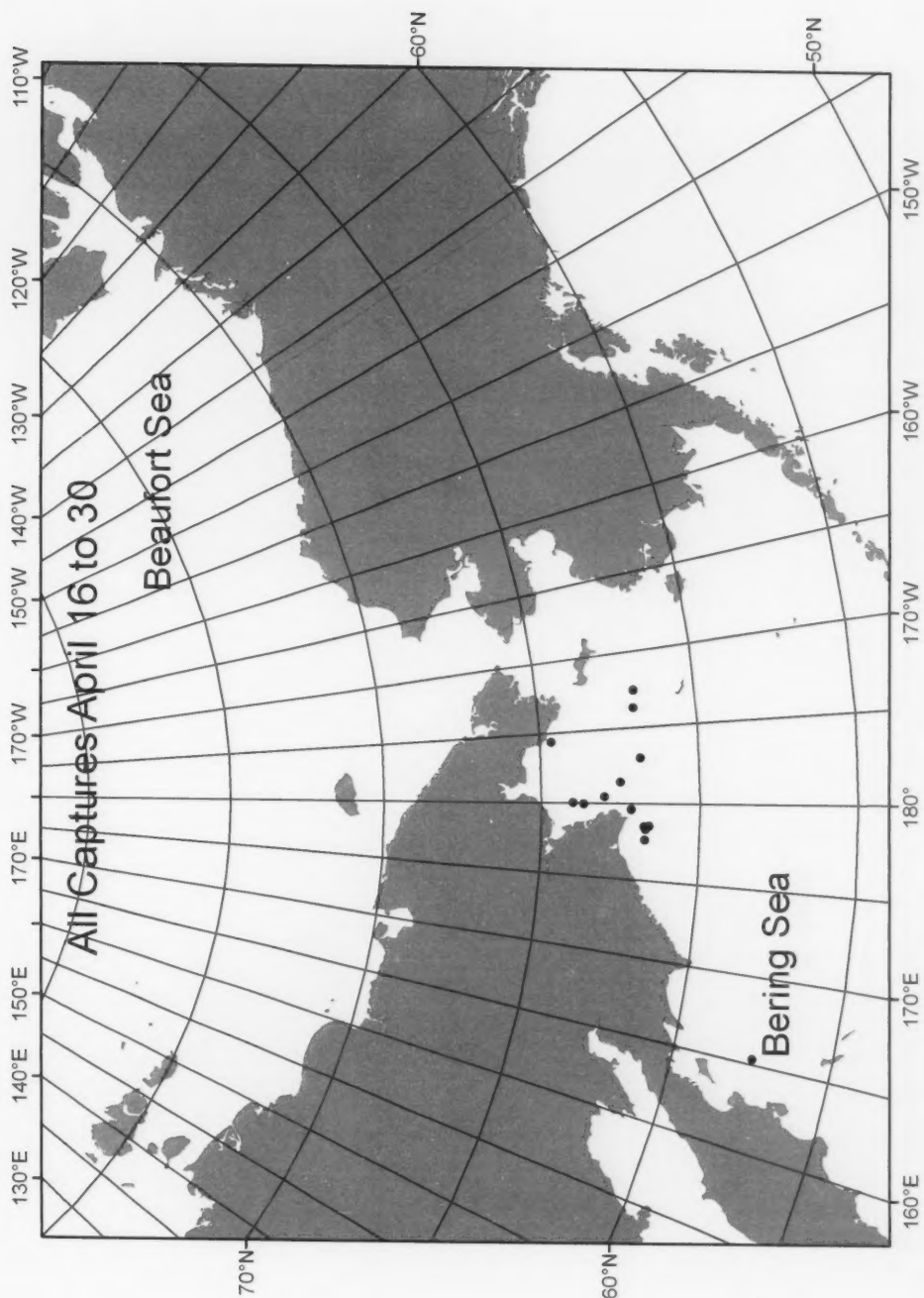
Map 16.—Documented captures of bowhead whales, 1904–08. During this 5-year period there were 71 cruises, of which 18 (25.35%) are documented in our database.



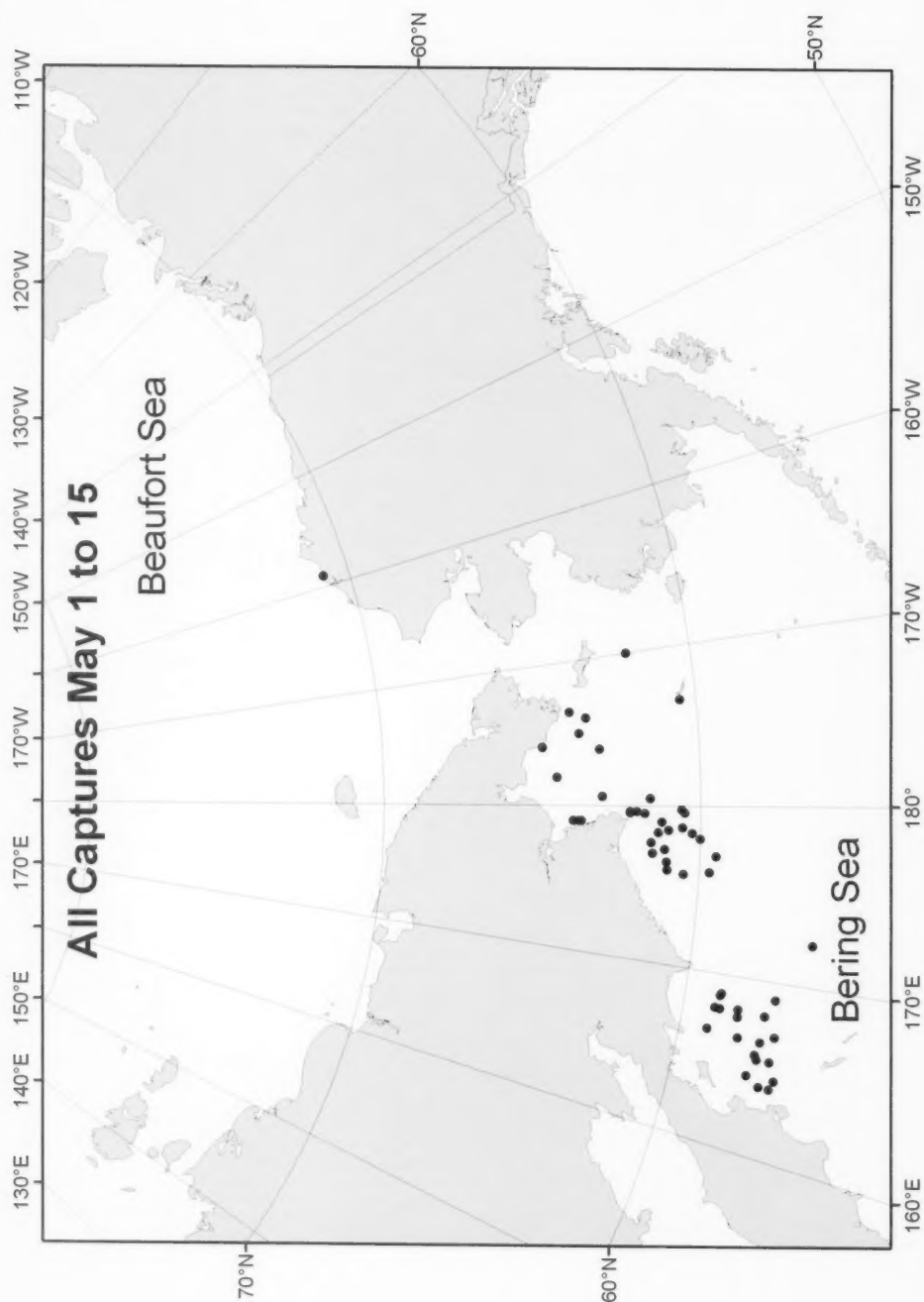
Map 17.—Documented captures of bowhead whales, 1909–13. During this 5-year period there were 24 cruises, of which 5 (20.83%) are documented in our database.



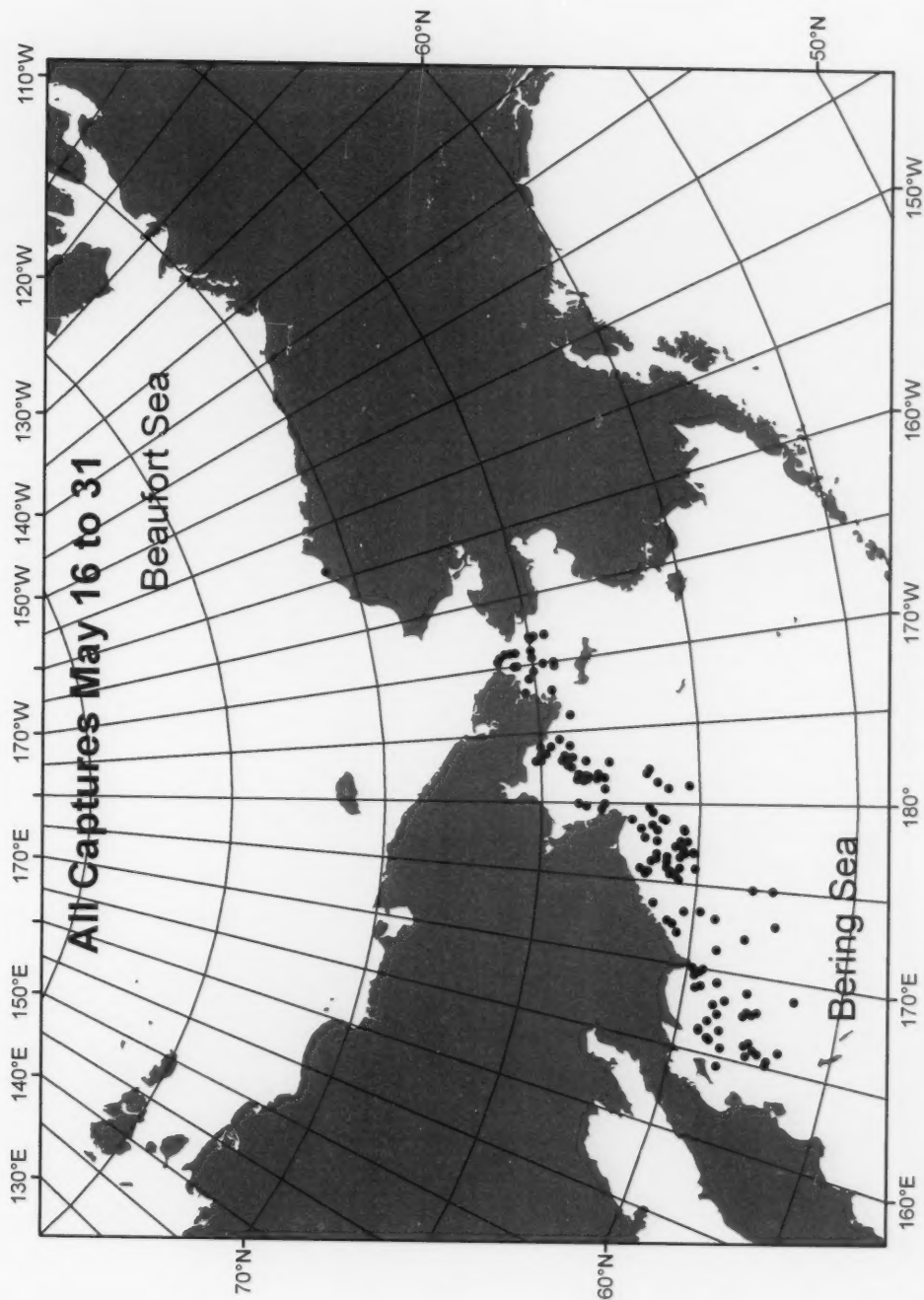
Map 18.—Documented captures of bowhead whales, 1914. During this year there were 4 cruises, of which 1 (25.00%) is documented in our database.



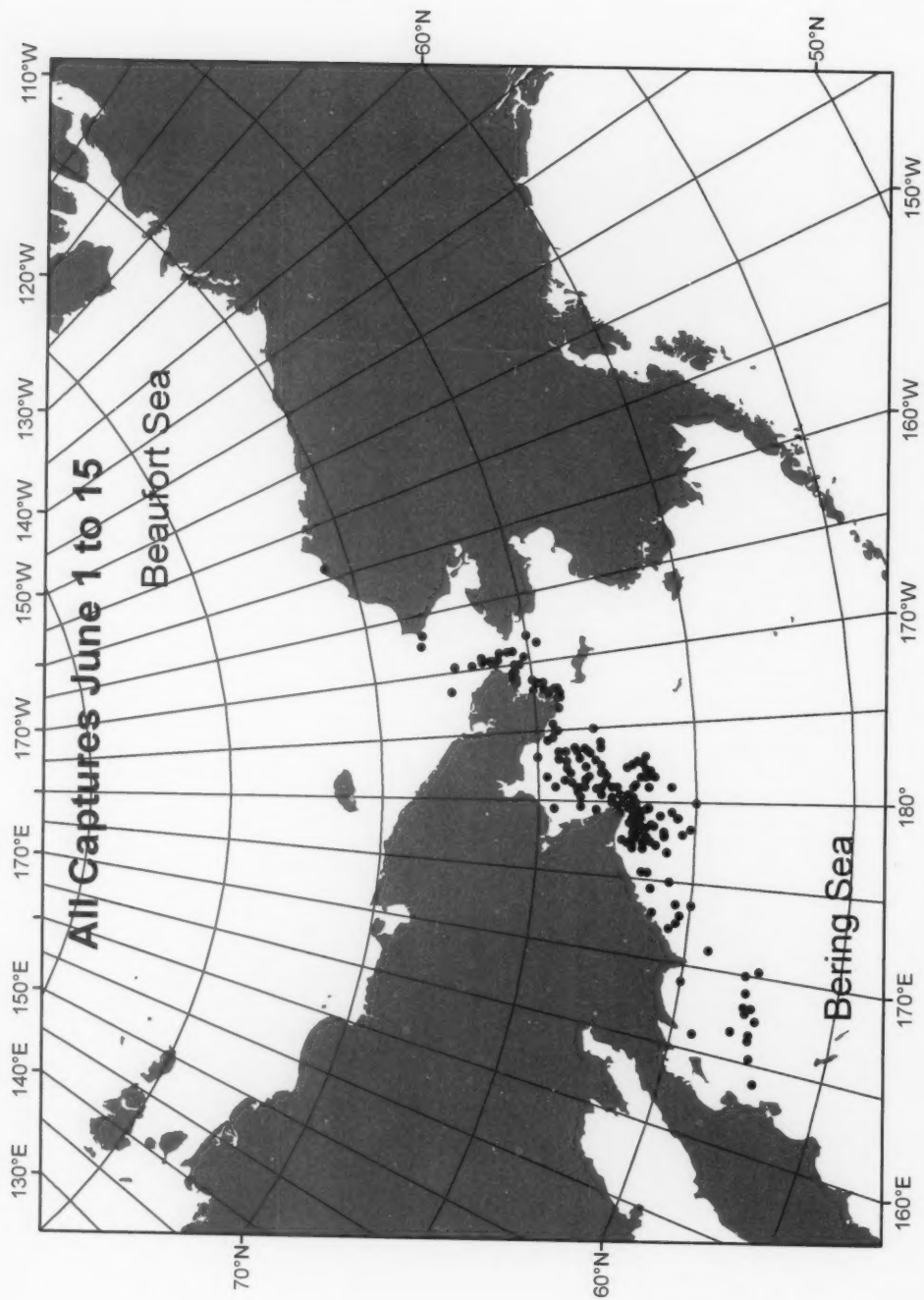
Map 19.—Documented captures of bowhead whales, 1849-1914; 16-30 April.



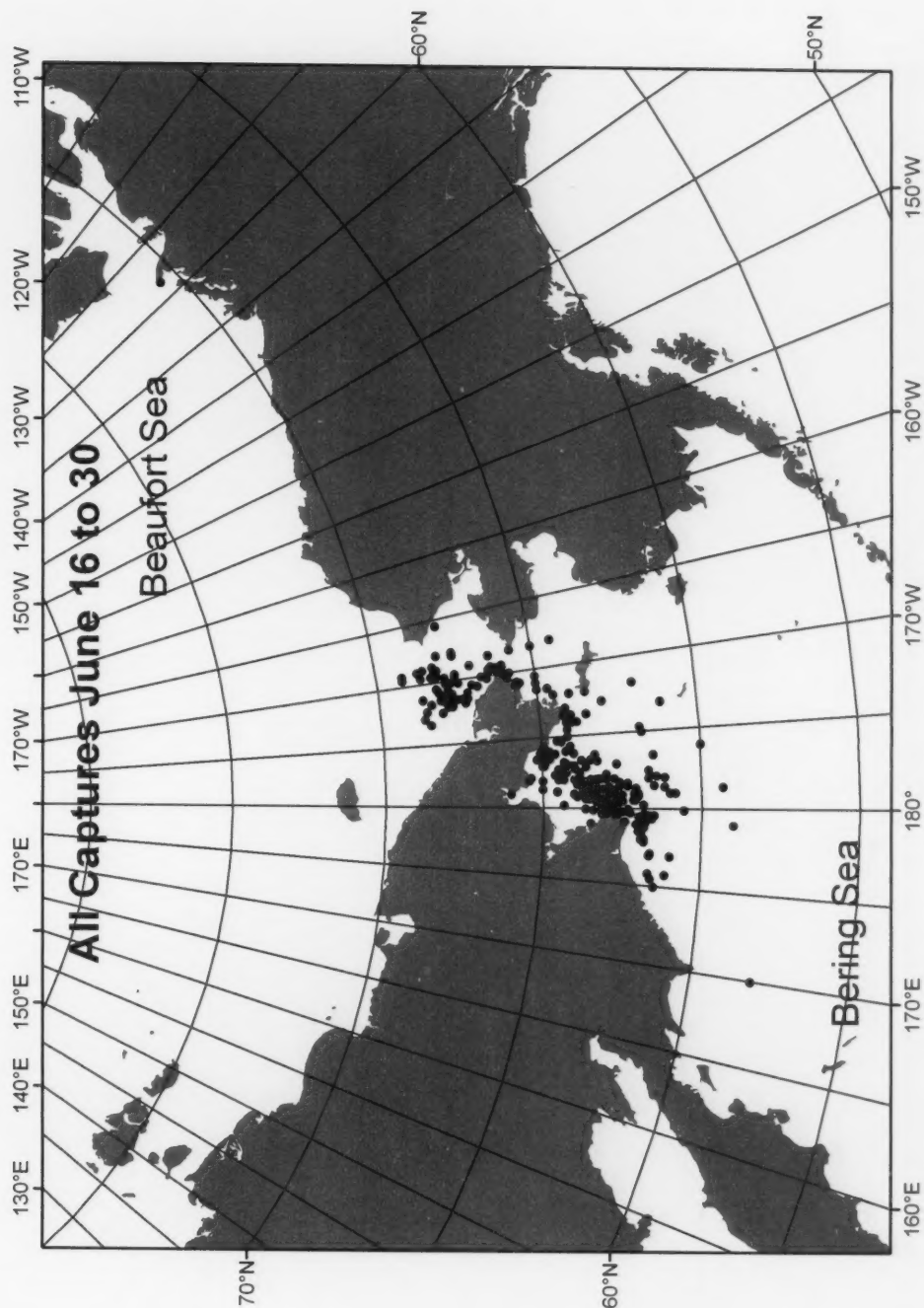
Map 20.—Documented captures of bowhead whales, 1849–1914: 1–15 May.



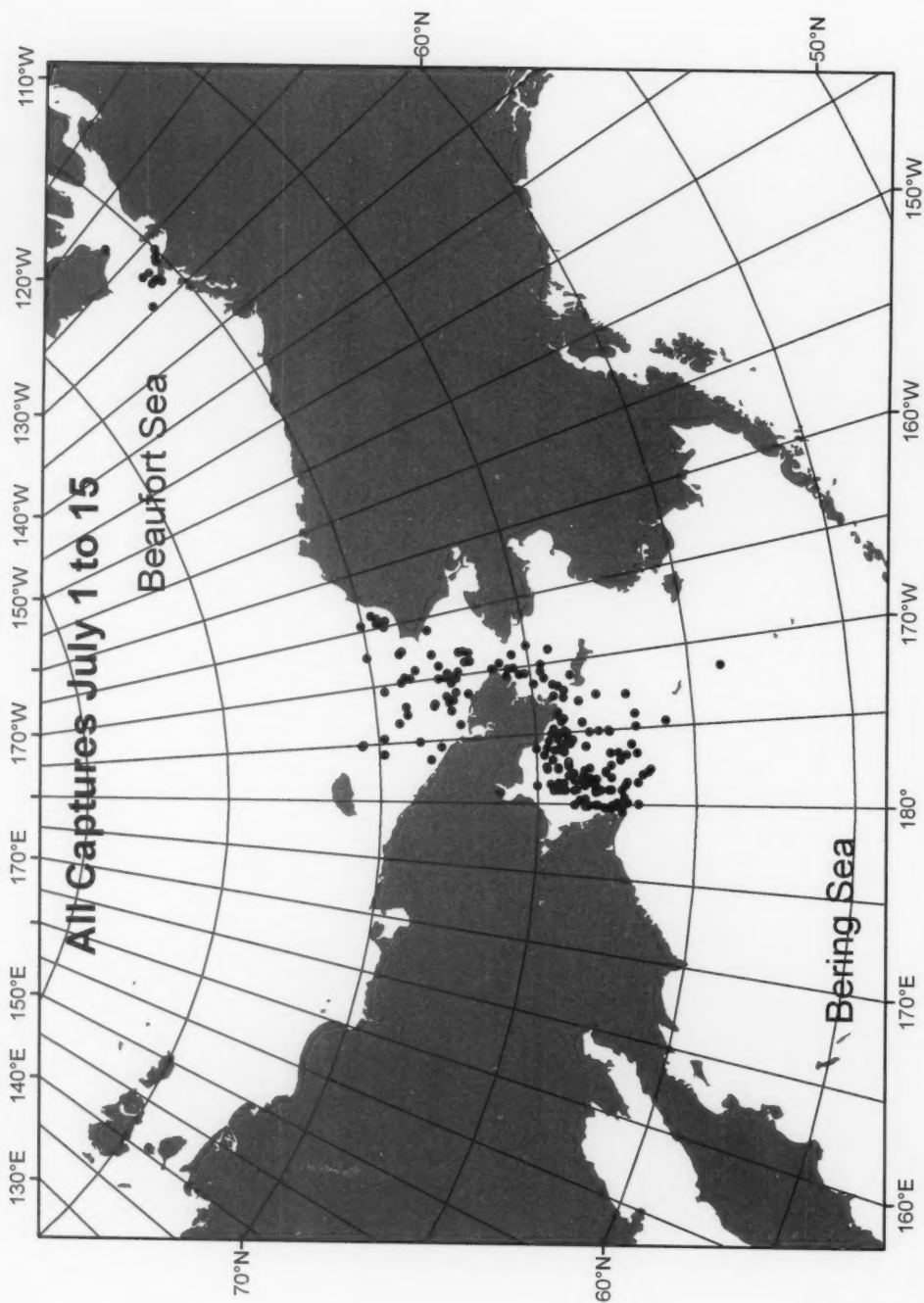
Map 21.—Documented captures of bowhead whales, 1849-1914; 16-31 May.



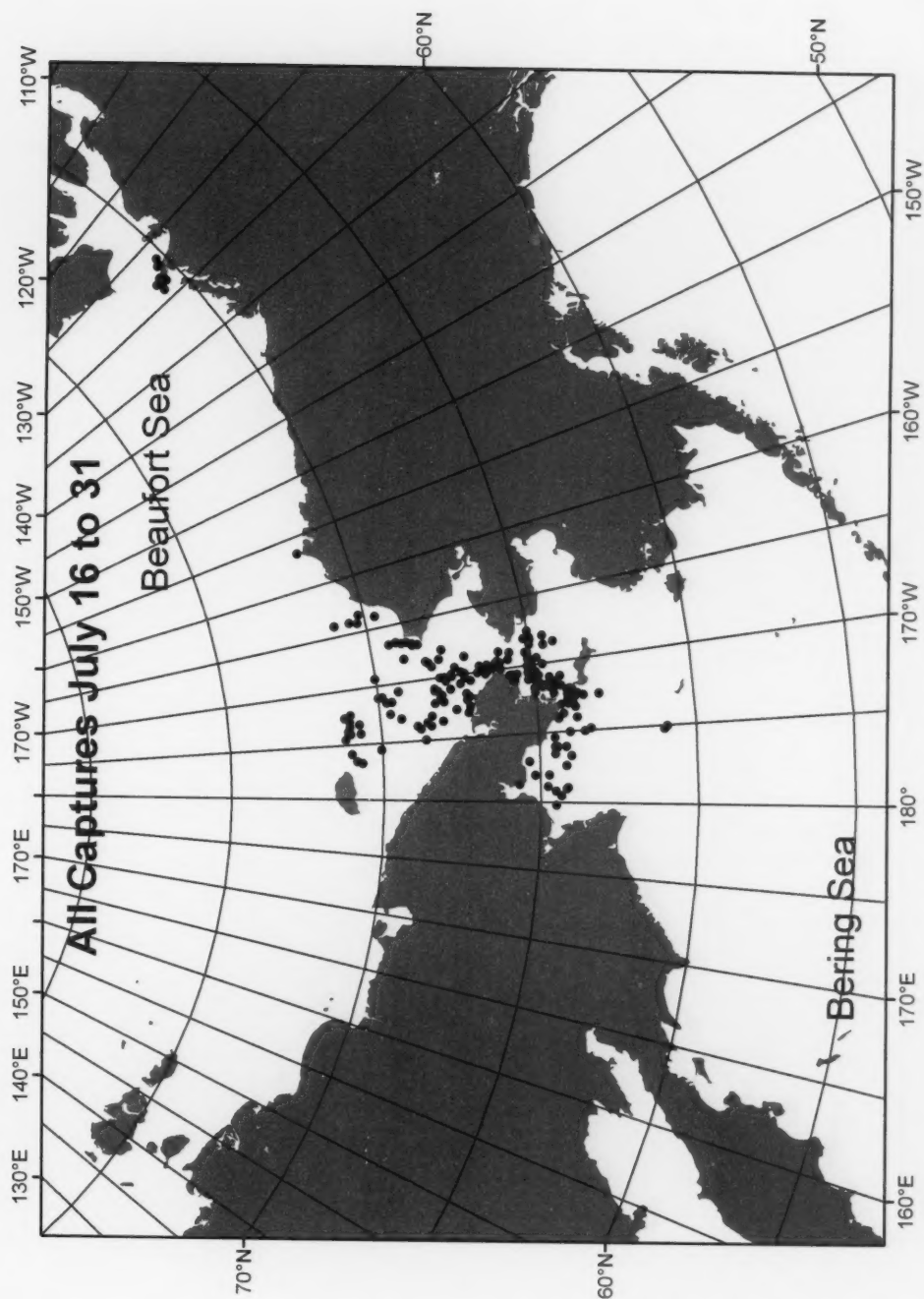
Map 22.—Documented captures of bowhead whales, 1849–1914; 1–15 June.



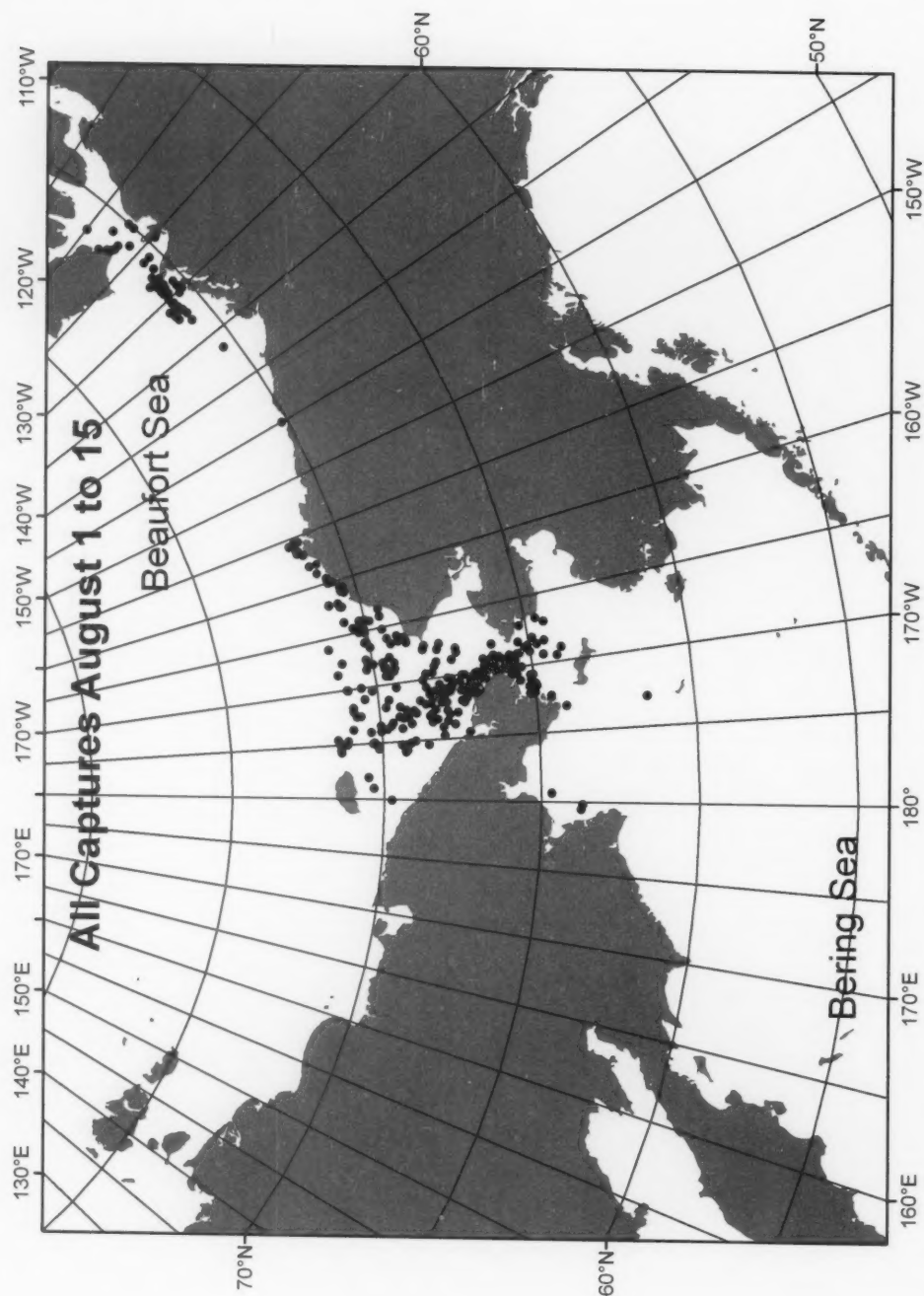
Map 23.—Documented captures of bowhead whales, 1849-1914; 16-30 June.



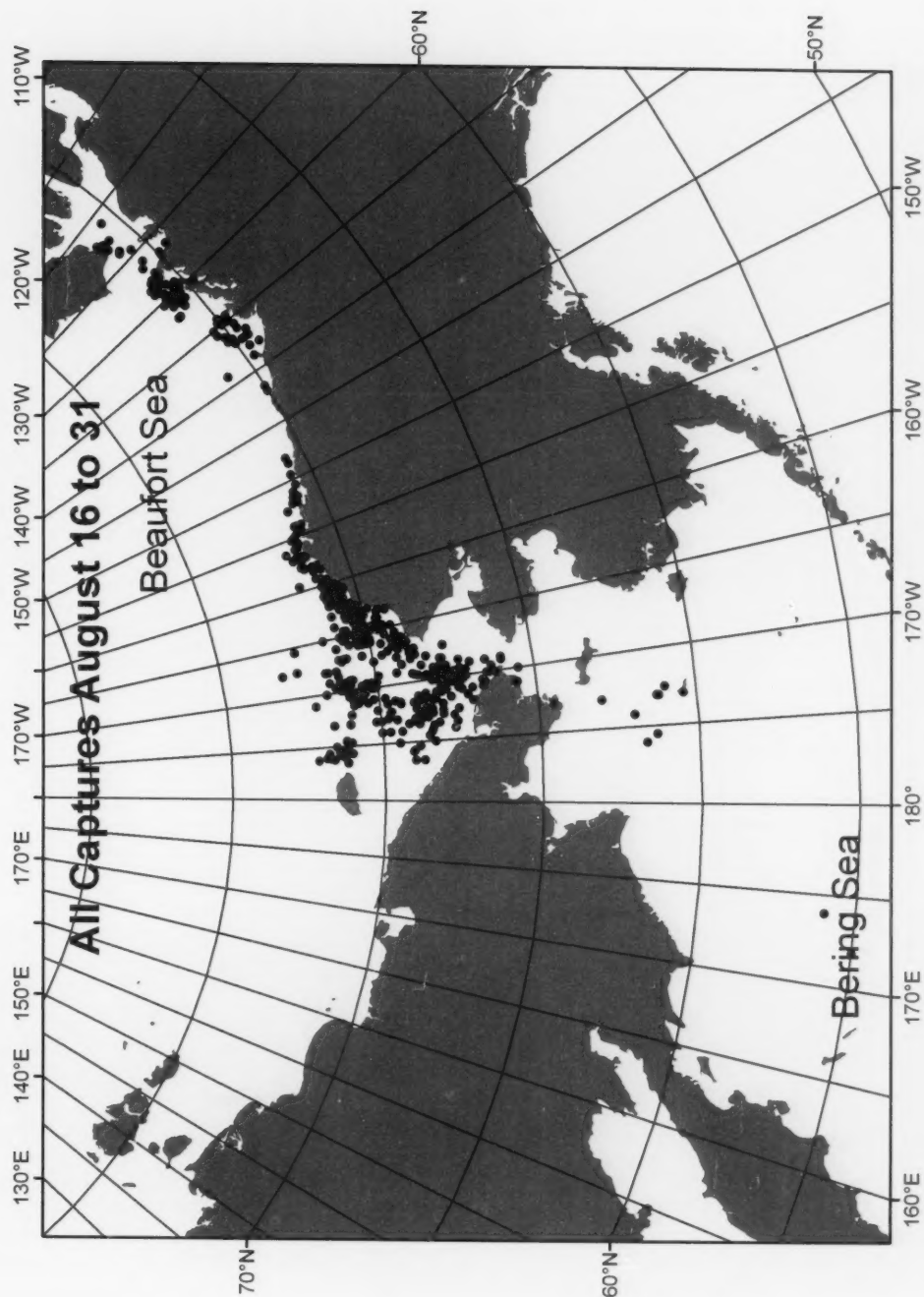
Map 24.—Documented captures of bowhead whales, 1849-1914; 1-15 July.



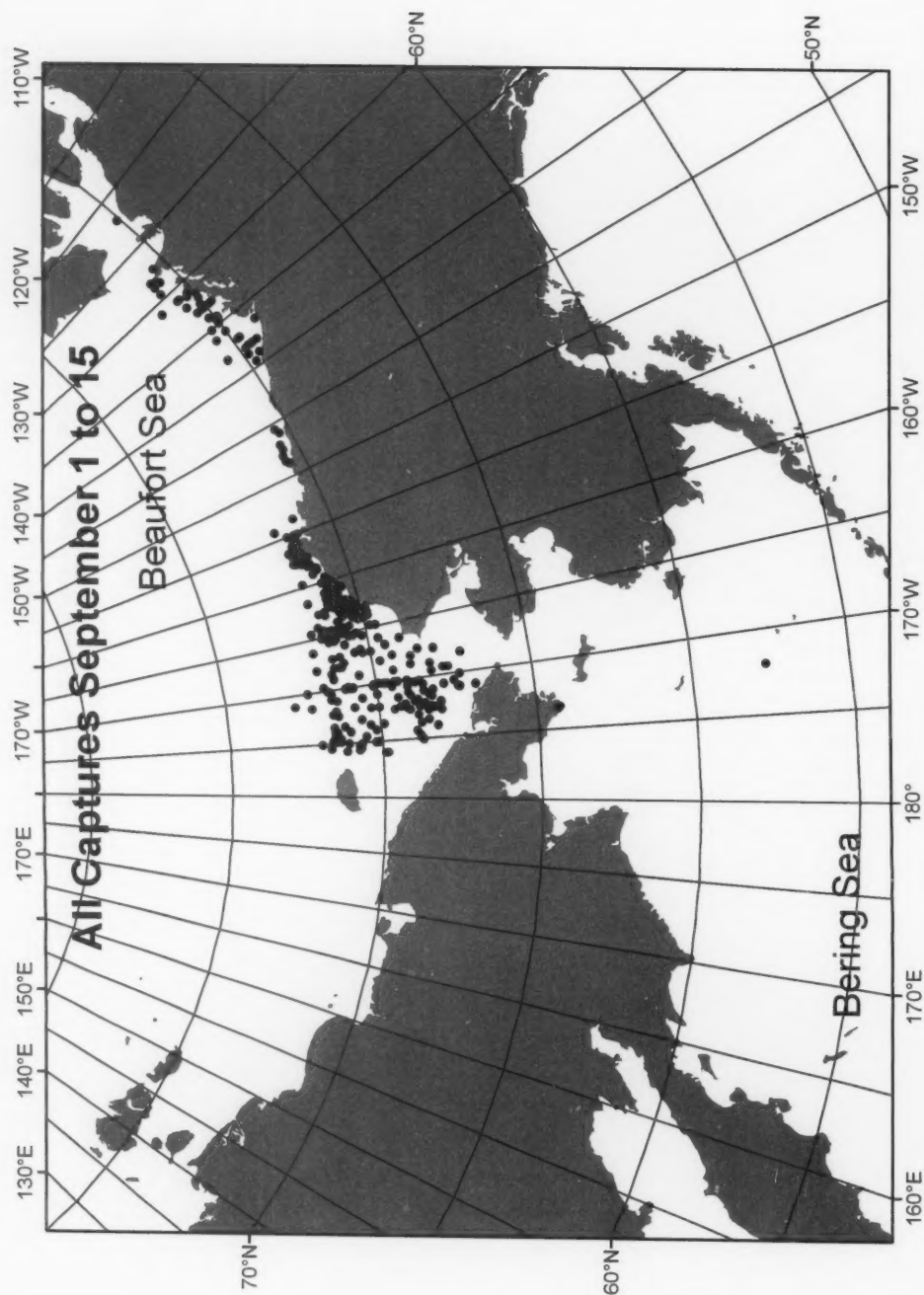
Map 25.—Documented captures of bowhead whales, 1849-1914; 16-31 July.



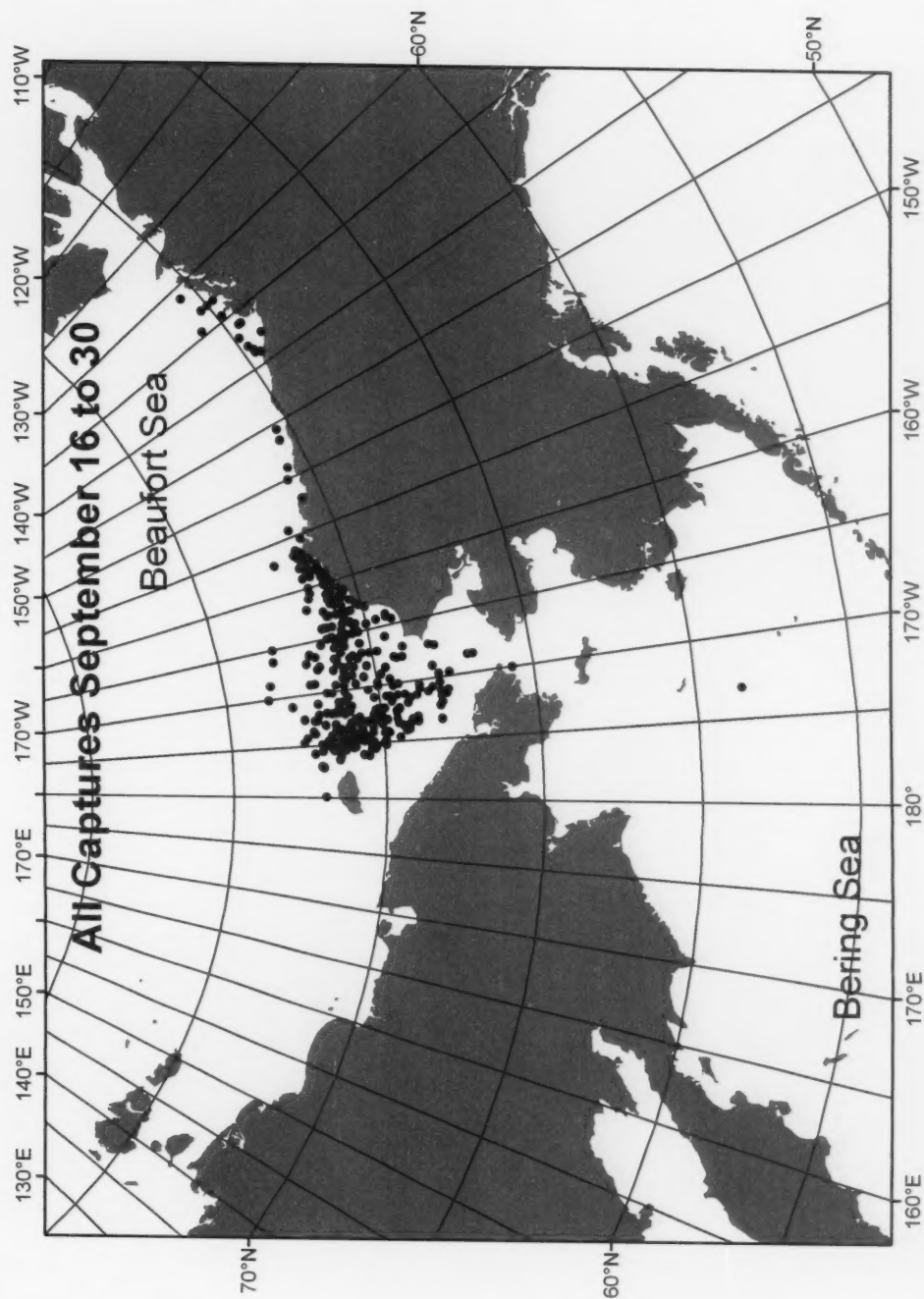
Map 26.—Documented captures of bowhead whales, 1849-1914; 1-15 August.



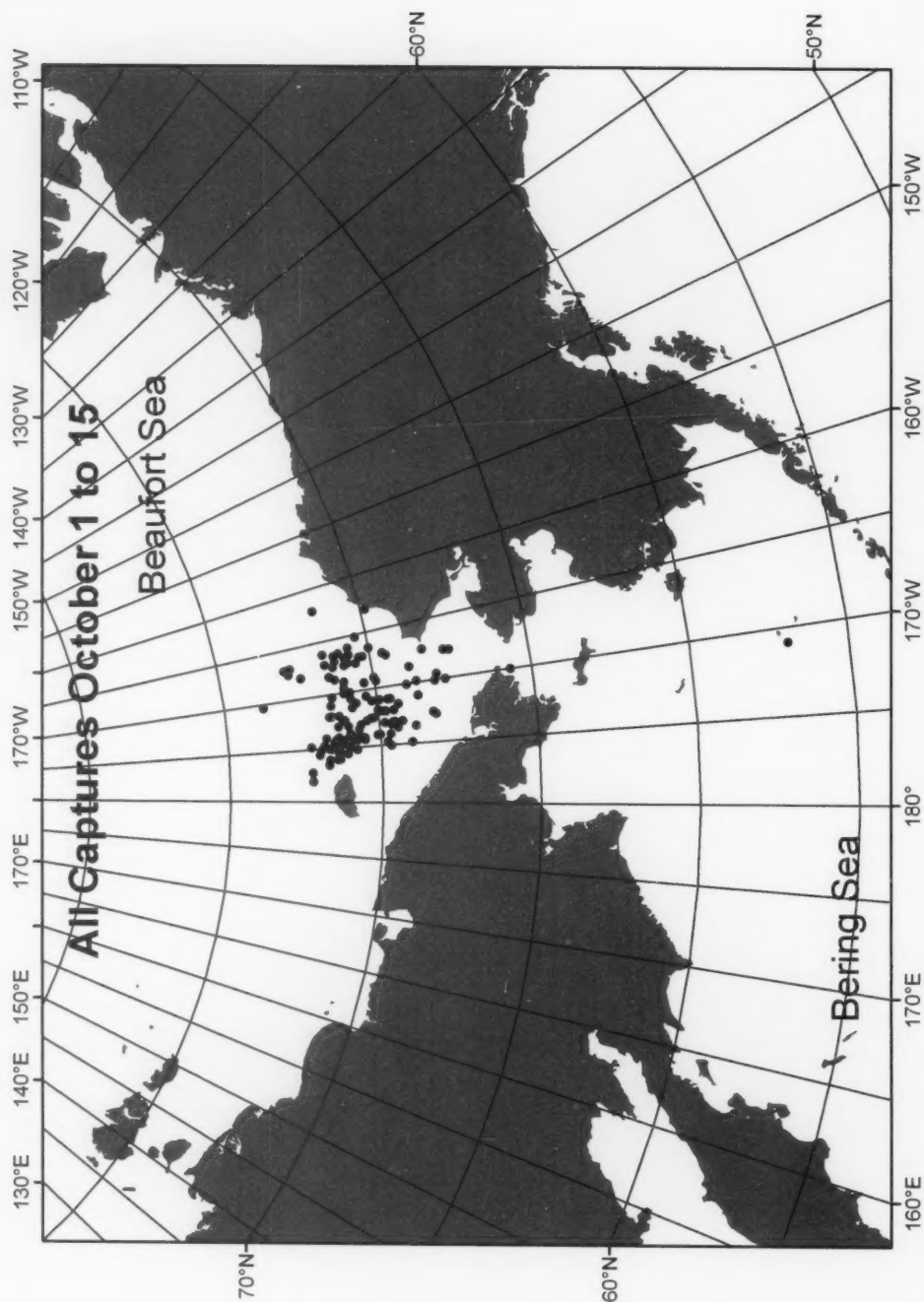
Map 27.—Documented captures of bowhead whales, 1849-1914; 16-31 August.



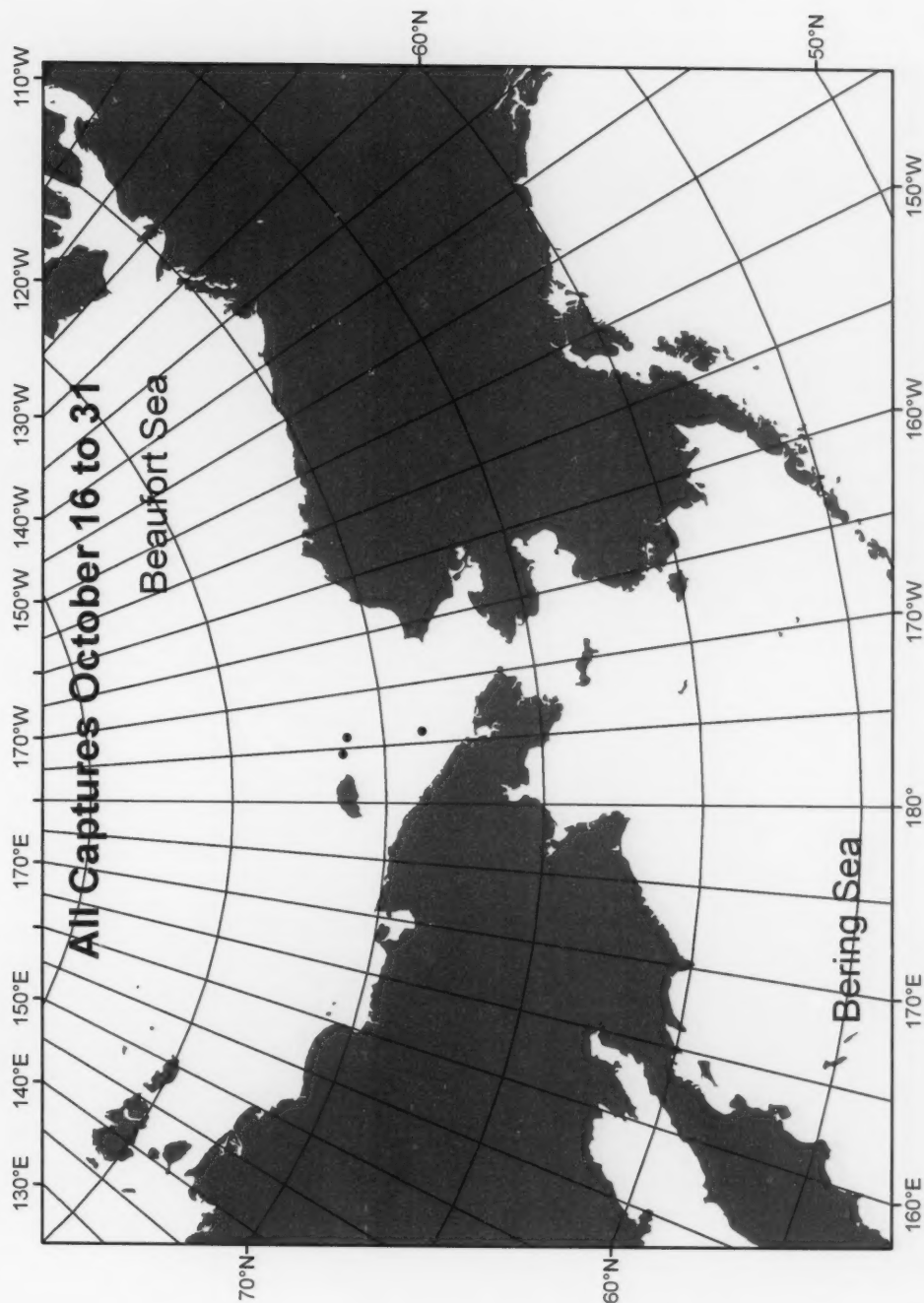
Map 28.—Documented captures of bowhead whales, 1849-1914; 1-15 September.



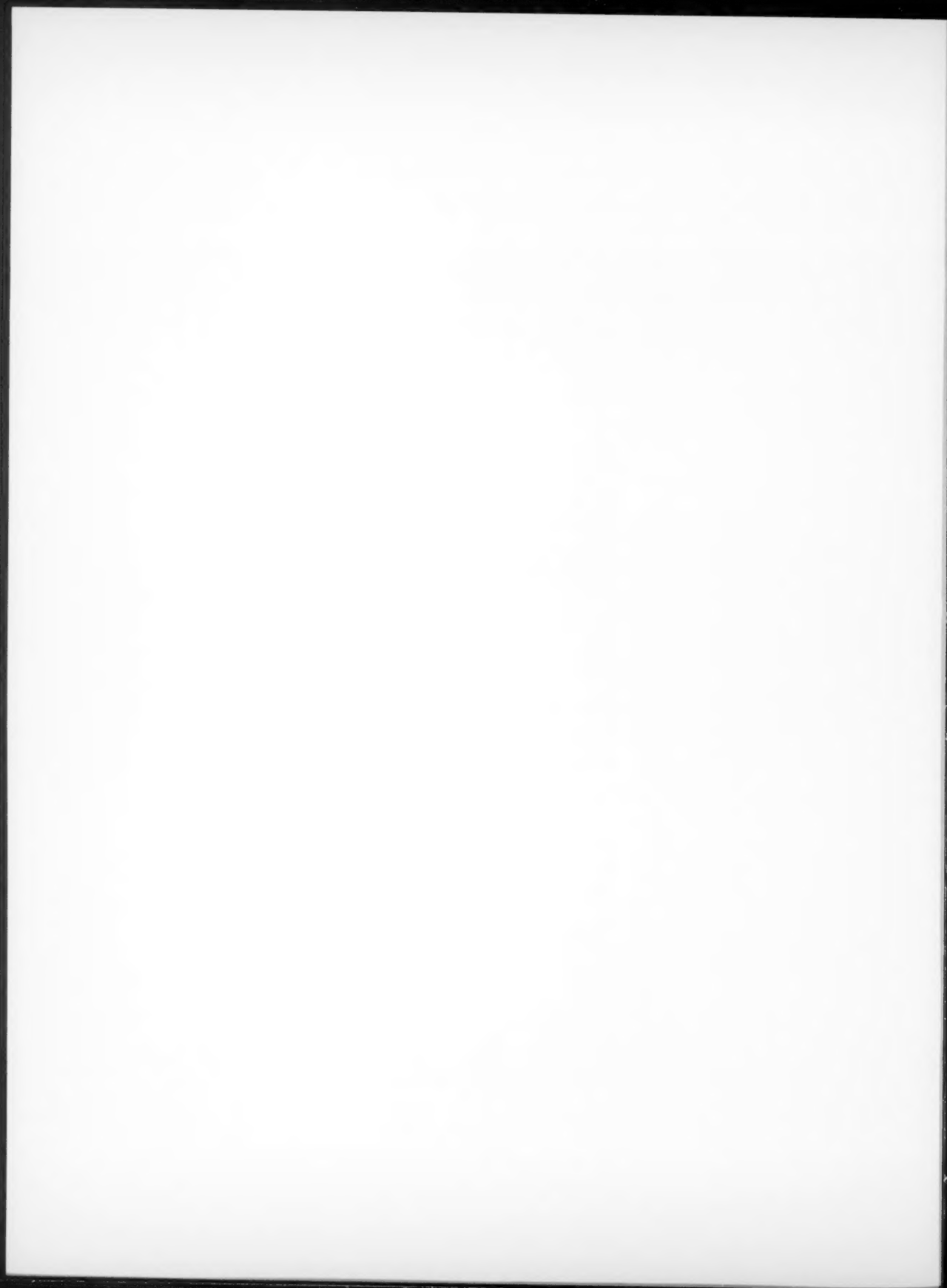
Map 29.—Documented captures of bowhead whales, 1849-1914; 16-30 September.



Map 30.—Documented captures of bowhead whales, 1849-1914; 1-15 October.



Map 31.—Documented captures of bowhead whales, 1849–1914; 16–31 October.



Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to the *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed double-spaced throughout and submitted with two duplicate copies. The complete manuscript normally includes a title page, a short abstract, text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, headings, subheadings, and the abstract short and clear. Because abstracts are circulated by abstracting agencies, it is important that they represent the research clearly and concisely. Headings within each section must be short, reflect a logical sequence, and follow the rules of multiple subdivision (i.e. there can be no subdivision without at least two items).

Style

The entire text should be intelligible to interdisciplinary readers; therefore, all acronyms,

abbreviations, and technical terms should be spelled out the first time they are mentioned. The scientific names of species must be written out the first time they are mentioned; subsequent mention of scientific names may be abbreviated. Follow the U.S. Government Printing Office Style Manual (1984 ed.) and the CBE Style Manual (5th ed.) for editorial style, and the most current issue of the American Fisheries Society's Common and Scientific Names of Fishes from the United States and Canada for fish nomenclature. Only journal titles, scientific names (genera and species), and vessel names should be italicized. Dates should be written as follows: 11 Nov. 1991. Measurements should be expressed in metric units, e.g. metric tons as t; other equivalent units may also be listed in parenthesis. Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. The numeral one (1) should be typed as a one, not as a lowercase el (l). Write out the numbers zero through nine unless they form part of measurement units (e.g. nine fish but 9 mm).

Footnotes

Footnotes should not be embedded within the text document. They must be numbered with Arabic numerals and typed on a separate sheet of paper. Footnote all personal communications, listing the name, affiliation, and address of the communicator and date of communication. Unpublished data and unpublished manuscripts should include the title, author, pagination of the manuscript or report, and the address where it is on file. Authors are advised to avoid references to non-standard (gray) literature, such as internal, project, processed, or administrative reports, wherever possible. Where these references are used, please include whether they are available from NTIS (National Technical Information Service) or from some other public depository.

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Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted.

Citations should be double-spaced and listed

alphabetically by the senior author's surname and initials. Coauthors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1979a, 1979b, 1979c, etc.). Authors must double-check all literature cited; they alone are responsible for its accuracy.

Tables

Tables should be printed separately and double-spaced. Tables should not be excessive in size and must be cited in numerical order in the text. Headings should be short but sufficient to allow the table to be intelligible on its own. All unusual symbols must be explained in the table heading. Other incidental comments may be footnoted with Arabic numerals. Because tables are typeset, they need only be submitted typed and formatted, with double-spaced legends. Zeros should precede all decimal points for values less than one. Table headings and format should be consistent; do not use vertical rules.

Figures

Figures include line illustrations and photographs (or slides) and must be cited in numerical order in the text. Figures are to be labeled with author's name and number of figure. Use Times Roman font (upper and lowercase letters) to label within figures. Avoid vertical lettering except for y-axis labels. Zeros should precede all decimal points for values less than one. Figures should be submitted as both laser-printed copies and computer software files. Figure legends should explain all symbols and abbreviations and should be double-spaced on a separate page at the end of the manuscript. Consider column and page sizes when designing figures. Please note that we do not print graphics in color.

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First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript to:

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